ILLUMINATING ENGINEERING

JANUARY 1955

In Two Sections — Section 1

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Electric Discharge Lamps for Street Lighting

Peripheral Glare and Its Effects

Design of High-Output F-Lamps

Graph for Utilization Data

Lighting Applications

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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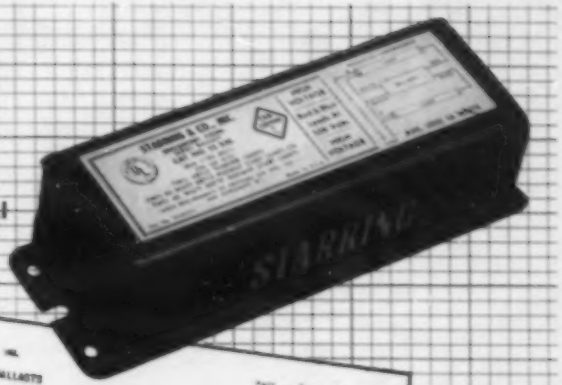

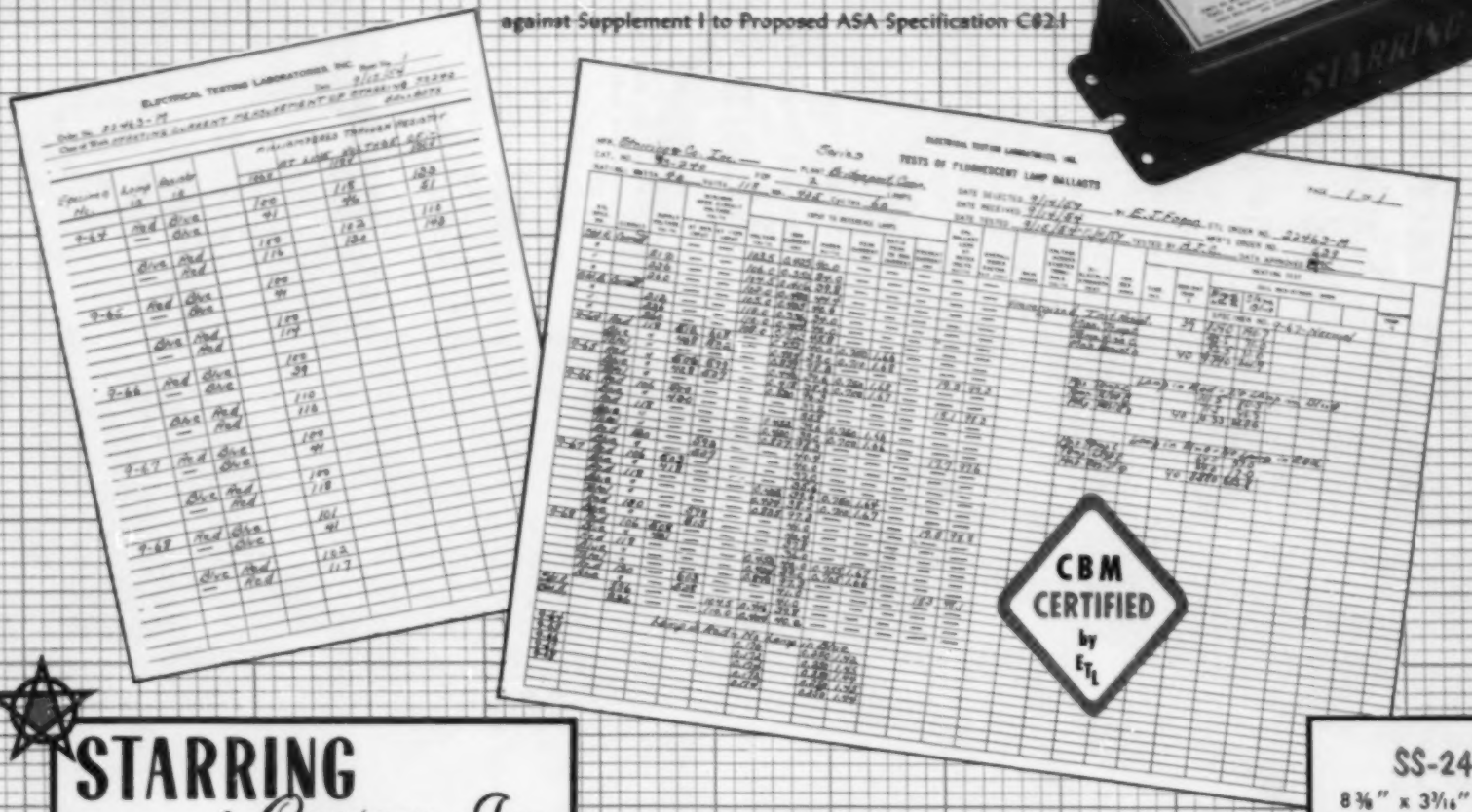

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

JANUARY
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Vol. L
No. 1

In Two Sections
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Interesting solutions to problems in lighting are often the winning factors in the local contests for "My Most Interesting Lighting Job." On the next four pages are shown three entries in this competition which feature . . .

Dairy Wonderland

New Wrinkles in Lighting Application

In Dairy Wonderland — Michigan Section

PSYCHOLOGY entered into the layout for the lighting system shown here. Within the one store are three separate merchandising areas — candy, ice cream and hot food. Subtlety in the lighting applied has been used to differentiate these variations, with good effect.

Both color of source and varying levels have been used to "lead" the customer to the different areas. A cool quality from cool white fluorescent indicates the cold food areas. Warm quality from incandescent emphasizes the warm foods. Light is concentrated over each area in varying degrees, and an overall high level studiously avoided.

Candy is considered the main item in the establishment, and is so featured by concentration of the store's highest lighting level. Here over 200 footcandles highlight the Candy Isle. Recessed incandescent downlights are used in an "isle-like" pattern.

Over the ice cream counter, to the right, a line of cool white fluorescent has been used, with psychology aforethought, to lead traffic to and through the frozen foods and bulk ice creams. This continuous line of light, providing 65 footcandles, also serves the purpose of suggesting movement along this counter. Such continuous "moving along" is especially desirable with the owner's rather unique method of merchandising ice cream. Purchases are made of scoops of ice cream, and as the customer passes on down the counter he has the choice of assorted toppings and nuts displayed along the counter, on a sort of "make your own sundae" basis. The fluorescent system is not recessed at this point, from necessity rather than choice. Steel cross members did not permit recessing in that direction. However, the fact that fluorescent lighting occurs on two sides of the area provided an opportunity for balance.

Hot light luncheons from the hot food counter at the rear of the store are illuminated with still another system, and illumination level. Here food is displayed under 300-watt incandescent lens type units, of approximately 40 footcandles.

Lighting for the dining area booths was planned with the thought that it should be relaxing and inviting. This is accomplished with recessed equipment using 200-watt incandescent silver-bowl lamps for an indirect system. The level here is 15 footcandles.

The store featuring this interesting installation is "Dairy Wonderland" located in Oak Park, suburb of Detroit, Michigan. Lighting was designed by Edwin W. Miller of the Detroit Edison Company. The installation won for Mr. Miller second prize in the contest for "My Most Interesting Lighting Job" conducted by the Michigan Section of I.E.S.

In Boyd's Store, Clayton, Mo.—

St. Louis Section

PROVISION of air distribution, sound control and lighting—preferably at a single stroke—was easier to say than accomplish in this area, remodeled from an ice cream retail outlet to an exclusive men's store. All three services were accomplished, however, in spite of a number of structural problems. The successful solution described won first prize for Henry J. Poehling, City Sales Inc., St. Louis, Missouri, in the contest for "My Most Interesting Lighting Job" conducted by the St. Louis Section of I.E.S.

Originally the building was a single story structure used first as an automobile show room. During the war it housed the Ration Board, and later drifted into use as an ice cream outlet. Remodeling plans added a second floor to be used as office space, and a completely redone first floor with appearance to be in keeping with the store's exclusive line of men's higher priced clothes. Problems encountered: Air conditioning outlets were located on the east and west sides of the room, in the sides of the ducts. Two 8-inch deep beams running the length of the room offered a good air baffle to provide a downdraft of cold air, leaving the center of the room stagnant. When the slab was poured, electrical outlets were located in one row along the east side of the room, with the intention of installing continuous rows crosswise of conventional suspended fluorescent luminaires. Suspended fixtures would be entirely unsuitable here, however. Not only would such a pattern be incompatible with the atmosphere the architect wished, but suspended units were virtually out of the question with the ceiling height of only 11 feet 6 inches below the beams, and even less below the ducts.

A study of a number of alternative systems for solving these problems, together with the costs, settled on a design to suspend the ceiling just below the beams. This would conceal any wiring, and with the installation of a proper air diffuser would provide an uninterrupted flow of air across the entire width of the room.

An acoustic ceiling was installed, consisting of continuous extruded aluminum "T" members 24 inches on centers, and short cross extruded "T" members 48 inches on centers, suspended on simple

(Continued on page 4)

In Butchart's Garden—

Vancouver Island Chapter

LIGHTING to create beauty, as well as to reveal it has brought still further fame to the already famous Butchart's Gardens of Victoria, British Columbia. One of the world's truly great botanical gardens, Butchart's was created nearly fifty years ago by Mrs. R. T. Butchart, wife of the owner-manager of a cement making firm which quarried limestone from the area. Seeing the desolation wrought by the quarrying process, she vowed that where gaping holes existed she would create a garden of beauty. During the next quarter century Mrs. Butchart gathered together from all parts of the world countless beautiful specimens of shrubs, flowers and trees — and made of that desolate spot a wonderland of garden beauty. Management of the gardens has for some years been in the hands of her grandson, Ian Ross, who has spread still further the fame of the Gardens. Accomplishing his hope to create a night-time garden with its own distinctive entity, fell to Percy Fletcher, Canadian General Electric Company Ltd., Victoria, B. C. The installation, one small part of which is shown in the picture, won for Mr. Fletcher first prize in the contest for "My Most Interesting Lighting Job" conducted by the Vancouver Island Chapter of I.E.S.

General pattern of the lighting effects finally evolved include: moonlighting effects in some areas; much high-level lighting, of the order of 50 footcandles or more, to focus attention on the splashes of color in the beds; some general lighting for the lawn areas; and spotlights pointing into the immense colorful trees.

A survey showed that there are six entities to Butchart's Garden. 1. An immense Star Pond enclosed with Crytomeria Japonica trained in arches twenty feet high and bordered with English Boxwood. 2. A Japanese garden featuring dense foliaged trees such as Japanese maple, bamboo and fig palm. 3. Japanese tea houses, which vie with lily ponds for attention. 4. A very famous Rose Garden, of more than an acre in size. 5. Vast Lawns surrounding the estate lend a background to the Formal Italian Garden. 6. A Sunken Garden, which area sparked the whole lighting enterprise. Tall Arbourvitae and Silver Birch with an abundance of perpetual flower color make this a

(Continued on page 4)

Boyd's Store — *(Continued from page 2)*

14 gauge wire. This formed a grid of rectangles 24 inches wide and 48 inches long. Into each of the rectangles a fiber glass acoustic panel could be installed, with its exposed side requiring no painting or finishing. Panels could be omitted where desired, or removed at any time after installation. This provided a finished-looking ceiling with a finished ceiling panel having sound absorbing and insulating properties.

Replacement of any of the acoustic panels with the recessed fluorescent luminaire, of the type shown in the picture, provides a "custom-made" design which may be installed in any pattern desired. The luminaire, having plastic diffuser, is designed to fit the same aluminum grid opening, 24 inches by 48 inches, and the grid itself is used to support the fixture.

To make up a pattern believed to best fit this general area, the column spacing encountered, and the spacing requirements for good illumination, rectangles measuring 8 feet by 8 feet were selected to help foreshorten the length of the store, and add to the apparent width. Each of the fixtures was wired for three 48-inch long rapid start lamps. The center lamp in each fixture was wired on a single lamp ballast. All center lamps in each rectangle were wired on a separate switch. The two outside lamps in each fixture were wired on a two-lamp ballast. All outside lamps in each rectangle were controlled as a group. This arrangement allowed switching for a three-way choice of: one-third the fluorescent capacity; two-thirds of the fluorescent capacity, or 100 per cent. This flexibility provides three different levels of illumination, to suit the time of day and amount of traffic in the store.

On another switching arrangement, independent of the fluorescent lighting, an incandescent component is provided by louvered recessed downlights using reflector lamps, spaced symmetrically at the corners of each rectangle. The incandescent downlighting provides subtle shadow and depth quality to the system, and a flattering color component for selling and for color discrimination, and adds an interesting sparkle to the lighting effect.

The view shown is with both systems turned on. Illumination level ranges from 75 to 100 footcandles after nine months operation, during which no cleaning of equipment has been done.

Butchart's Gardens — *(Continued from page 2)*

favorite spot with visitors, and a difficult one to light.

Basic lighting system is with cone-shaped fixtures having metal hoods with a six-inch mouth and about 10 inches high. These were made to take a 75-watt R30 lamp and are placed below eye level mounted on conduit, making it easy to drive them into the ground. Illumination at bed level is about 75 footcandles. More than 200 of these units are used.

For the large areas of lawn a standard 20 feet high was designed which had for its light source a 300-watt symmetrical reflector. Experiments showed that spotlights in the lacy-leaved trees, such as the Japanese maple, created a beautiful display, particularly if some color was added in the form of an amber lens.

The sunken garden area seemed to demand that floodlighting be used to create something of a moonlighting effect. This was done by mounting four 1500-watt general purpose floods on 30-foot poles above the lip of the area. As this lip is 100 feet above the floor, a very high and virtually unobtrusive source was created. All in all, more than 40 kw of lighting is used, including numerous 150 or 300 PAR type floodlamps, all wired underground with some 20,000 feet of cable.

The effect of the lighting is entrancing. Iris spotlighted against the blackness of a pool; Japanese plum and silver maple from concealed sources; a splash of red colored prunis pasardi dramatized still further with 150-watt PAR spot and an amber lens. Carefully designed lighting effects have brought to the famous garden a fairy-like quality which fascinates the visitor and completely pleases the owner.

Design of High-Output Fluorescent Lamps

By A. C. BARR
W. J. KARASH

EVER since the introduction of fluorescent lamps, lighting designers have been aware that higher-output lamps would offer real advantage in many applications. Their availability would permit higher levels of illumination in applications where size or number of lighting fixtures must be limited for maintenance reasons, because of effect on room appearance, or due to space limitations. Their ability to maintain light output at low temperatures would make them useful for outdoor applications as well.

Lamp design engineers have been aware of this need; the 100-watt T17 lamp was a reasonably successful effort to meet those requirements. However, elimination of starters, still higher light output, and lamp dimensions better suited to a wide variety of fixture designs and application requirements were needed before fullest advantage could be taken of the high-output principle.

Over the years many new designs have been tried in the laboratory. Until recently, none of them were adopted because economic analysis indicated lighting costs would be too high. These unfavorable economics were due to three factors: ballast size and losses, lumen maintenance, and heating effects in fixtures.

Ballast economics for instant-start operation were unfavorable because the use of higher current, inherent to high-output design, results in marked increase in ballast size and losses. Further, higher current reduces lamp operating voltage, because of the negative resistance characteristic of discharge lamps. Since the required starting voltage is independent of lamp operating current, the ballast must be designed to absorb a greater difference between starting and operating voltages.

Heavier lamp loading also adversely affects lumen maintenance and increases bulb wall temperature.[1,2] Unless the general level of lumen maintenance is very high, lighting economics for high output again tend to be unfavorable. And, unless fixtures designed for indoor applications provide good ventilation to the lamps, losses in light, due to increased lamp temperature, further increase lighting costs.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 13-17, 1954, Atlantic City, N. J. AUTHORS: Application Engineering Department, and Lamp Development Laboratory, respectively, General Electric Company, Lamp Division, Nela Park, Cleveland, Ohio.

In recent years there have been important improvements affecting all three factors. Now rapid-start design, improved lumen maintenance, and well ventilated fixtures all contribute to more favorable economics for high-output lamps.

Design Factors

The lamp engineer must evaluate the effect of many parameters before arriving at a final design. The most important of these parameters are lamp length, bulb diameter, lamp operating current, filling gas, and circuiting. Each must be weighed for its effect on mean light output, manufacturing practicability, ballasting requirements and lighting economics. This paper presents the effects of these parameters on lamp characteristics and ballast requirements and then shows how the choice of values affects lighting economics.

Light Output

The light output of fluorescent lamps is not a linear function of lamp current. The departure from linearity becomes greater as current increases, until a point is reached where further increase in current fails to produce an appreciable increase in light output. A substantial part of this departure from linearity at the higher currents is due to higher bulb wall temperatures associated with increased lamp loading (watts per unit area of bulb wall surface).[2,3,4,5,6,7,8,9] Other factors entering into the departure from linearity are the somewhat interrelated effects of multi-stage ionization, changes in electron temperature, absorption of 2537Å radiation by mercury atoms (quenching effect), and changes in the excitation and ionization probabilities.

Fig. 1 shows the variation of light output with lamp current for several lamp diameters and filling gases. As expected, the departure from linearity at the higher currents is greater for T8 lamps and least for T17 lamps. Krypton lamps, because of lower gas losses, are less heavily loaded at a given current than similar argon lamps.[10] Accordingly, they show slightly less departure from linearity.

At low lamp currents, bulb wall temperatures for all lamps are below the optimum value for most efficient of 2537Å radiation.[5] At these lower currents, the bulb wall temperature of the T8 lamp,

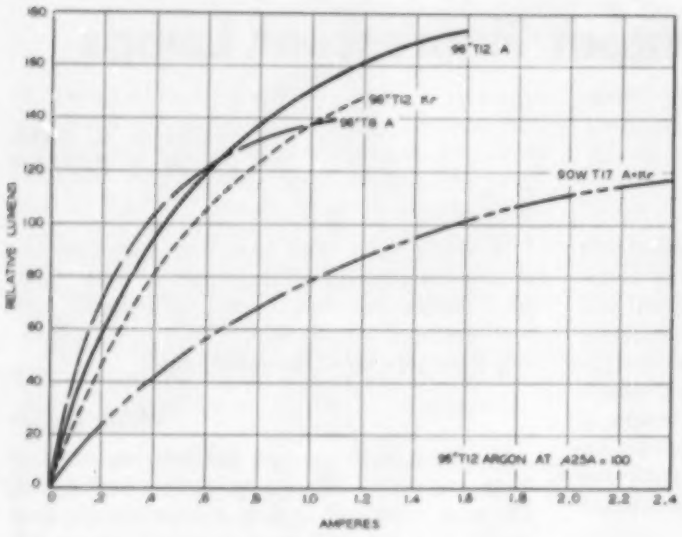

Figure 1. Light Output vs. Lamp Current. — Increasing lamp current brings large gains in light output when current density is low. At high current densities, gains are relatively small. Tube diameter, lamp length and gas filling also affect total light output.

due to its higher loading, is nearest to the optimum value. This greater efficiency in generation of 2537Å radiation, coupled with higher lamp watts, accounts for the higher lumens at the low currents for the T8 lamp.

For high-output fluorescent lamps, the choice of operating current must of necessity be a compromise between higher light output and better economics. This compromise point for T12 argon lamps lies in the vicinity of 0.8 amperes; lower currents sacrifice lumens, higher currents sacrifice efficiency. Data given later in this paper will show this to be the operating current for best indoor performance. Based on the slopes of the light output curves, estimated similar points for the other lamps are approximately 0.4 ampere for the T8 lamp, 1.0 ampere for the T12 krypton lamp, and 1.6 amperes for the T17 50 per cent argon - 50 per cent krypton lamp.

Fig. 1. shows that for current above 0.65 amperes, the 96T12 argon lamp produces the greatest light output. Below that current the T8 lamp has a slight advantage. However, any increase in ambient temperature, such as frequently occurs when lamps are enclosed in fixtures, would reduce the current at which equal light outputs are obtained, and would increase the advantage for the T12 lamp at higher currents.

Fig. 1 also indicates that 96T12 argon lamps produce approximately 40 per cent more light at 0.8 ampere than at 0.425 ampere. 96T12 krypton lamps, for equal light output, require 1.0 ampere. This means a 25 per cent increase in ballast current capacity with a consequent substantial increase in ballast size and losses. For 90WT17 lamps (nominal length 60 inches) still higher currents are needed.

If a 96T17 lamp were feasible, its curve (not shown) would cross the 96T12 argon lamp curve at about 1.7 amperes. When compared at 0.8 ampere, the 96T17 lamps would give 20 per cent less light than 96T12 argon lamps. For equal light output, 96T17 lamps would require 1.1 amperes, a 35 per cent increase in lamp current.

For high lumen output, Fig. 1 indicates quite strongly that of the lamps considered the 96T12 argon lamp is the best design choice.

The data in Fig. 1 can be used to calculate lumen outputs for other lamp lengths. To a reasonably close approximation, lumen outputs for lamps with similar bulb diameters and filling gases is directly proportional to the spacing between electrodes (90 inches for 96T12 lamps, 54 inches for 90WT17 lamps).

Lamp Volts[1, 13]

The relationship between lamp voltage and lamp current poses certain limitations on ballast design. For all currents below the operating value, the available ballast voltage must exceed the lamp voltage.[11, 12] The ballast must be designed so that its characteristic curve intersects the lamp voltage characteristic curve at the specified operating current.

Fig. 2 shows voltage *vs* lamp current characteristic curves for several lamp designs. It is seen that for a given current, lamp volts increase with decreased tube diameter. As has been shown, krypton lamps, due to lower gas losses, have a lower voltage than similar argon-filled lamps.[10]

Lamp voltages for other lamp lengths can be calculated using the following formula:

$$\text{Lamp Volts} = V_e + K_1 L_e$$

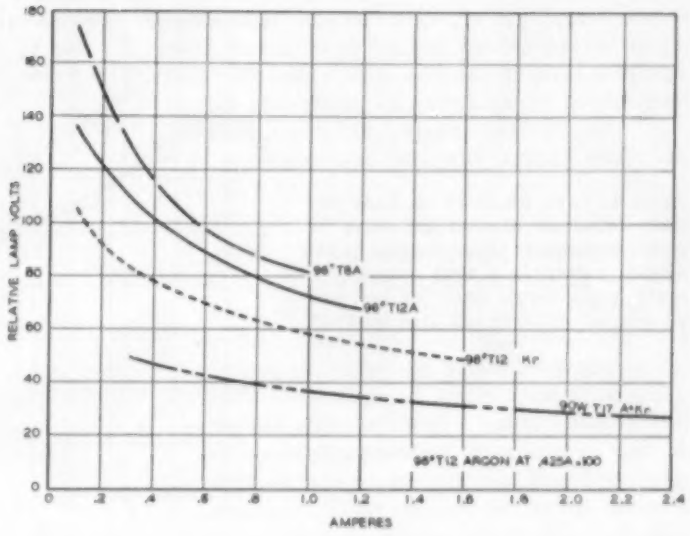

Figure 2. Lamp Operating Voltage vs. Lamp Current. — Unlike starting voltage, lamp operating voltage is lowered when higher currents are used. Other factors: length, diameter, and gas filling, affect both.

where V_e = electrode volts

K_1 = a constant which depends on lamp current, bulb diameter, and filling gas.

L_c = column length (approx. electrode spacing — 0.8 tube diameters).

V_e = varies slightly with lamp current. However, if the following values are used, calculated lamp voltages will not be seriously in error for lamps of reasonable length: T8, T12, and T17 argon—17 volts; T12 krypton—13 volts; T17 argon + krypton—14 volts. The values for $K1$ at the various currents can be calculated from Fig 2 and published values of lamp voltages at standard currents.

Lamp Watts

Lamp wattage and ballast losses constitute the total input wattage; the sum of the two is a direct determinant of system efficiency. The relationships between lamp wattage and lamp current are shown in Fig. 3. Since lamp watts are a function of the product of lamp volts and lamp current, lamp watts decrease with increasing bulb diameter or use of krypton gas.

Lamp watts for other lamp lengths can be calculated by use of the formula:

$$\text{Lamp Watts} = V_e I + K2L_c$$

where V_e = electrode volts, previously given.

I = lamp current in amperes.

K_2 = a constant which depends on lamp current, bulb diameter, and filling gas. K_2 takes into account voltage gradient and power factor.

L_c = column length.

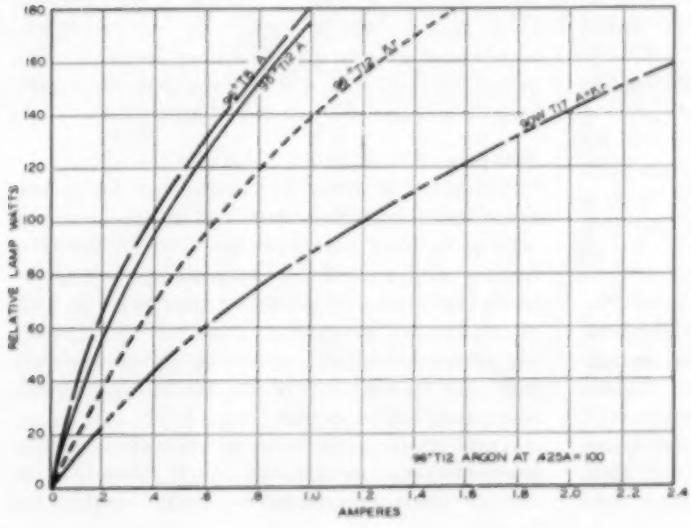

Figure 3. Lamp Wattage vs. Lamp Current. — Comparison with Fig. 1 shows that wattage increases faster than light output, particularly at the higher current densities.

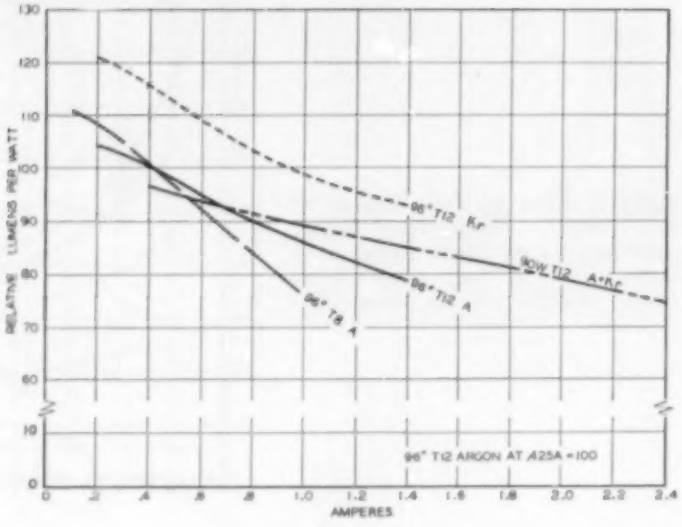

Figure 4. Lamp Efficiency vs. Lamp Current. — Although Krypton gas filling improves efficiency at higher currents, it also reduces wattage and light output. The 96T12 Argon design offers the best combination of efficiency and high light output.

The values of K_2 at the various currents can be calculated from Fig. 3 and published values of lamp watts at standard currents.

Lamp Efficiency

Comparison of Fig. 3 and Fig. 1 shows that the lamp wattage and light output characteristic curves have somewhat similar shapes. The greater departure from linearity of the latter accounts for decreased lamp efficiency at higher currents. Fig. 4 shows the variation of efficiency with lamp current. Lamp efficiency increases with decreased lamp current and is higher for krypton-filled lamps than for similar argon-filled lamps.[10] The slope is greatest for the T8 lamp and least for the T17, a direct consequence of the difference in loading.

While krypton lamps are more efficient at equal current, this advantage is lost when overall system efficiency is compared on an equal light output basis.

Lamp efficiency characteristics for other lengths can be calculated directly from calculated values of lumens and lamp watts. Efficiency is lower for short lamps, due to the greater effect of electrode losses.[1] For example, the efficiency of a 48T12 lamp is approximately 10 per cent lower than that of a similar 96T12 lamp.

Mean Lumens

Although it is customary to compare initial (100-hour) lamp output, economic studies are usually made on a more realistic basis; mean lumens throughout life. Lumen depreciation increases with lamp loading,[1] so any study of high output design must give careful consideration to this effect. Both initial lumens and lumen maintenance have been improved steadily during recent years.[14] At the same time the differential associated with heavier loading has also been reduced. It is this narrowing of the gap between the lumen maintenance at normal and at higher lamp currents that makes higher output fluorescent lamps much more attractive than in the past.

Fig. 5 shows how mean lumens are affected by lamp current in 96T12 argon-filled lamps. Mean lumens are compared with initial lumens using 0.425 amperes as a reference point. The ratio of the two curves shows that at 1.0 ampere lumen maintenance is reduced only some 4 per cent below the value at 0.425 amperes. For currents between 1.0 ampere and 0.425 ampere, the decrease in lumen maintenance is correspondingly smaller.

At equal light output, lumen maintenance of the 96T8 and the 90-watt T17 lamps is substantially lower than the 96T12 argon lamp — a direct consequence of greatly increased lamp loading.[1] The 96T12 krypton lamp has a slight, but not significant, advantage over the 96T12 argon lamp.

Ballasting

The economics of any fluorescent lighting system are affected by ballast costs and wattage losses as well as by lamp characteristics. Indeed, the need for practical and efficient ballasting is one of the most important considerations in designing high output lamps. Open circuit voltage (O.C.V.) starting requirements, lamp operating voltage and current, and starting method are the principal determinants of ballast design.

Three starting methods are available; switch-start, instant-start, and rapid-start. Since elimination of starters is considered most desirable, the

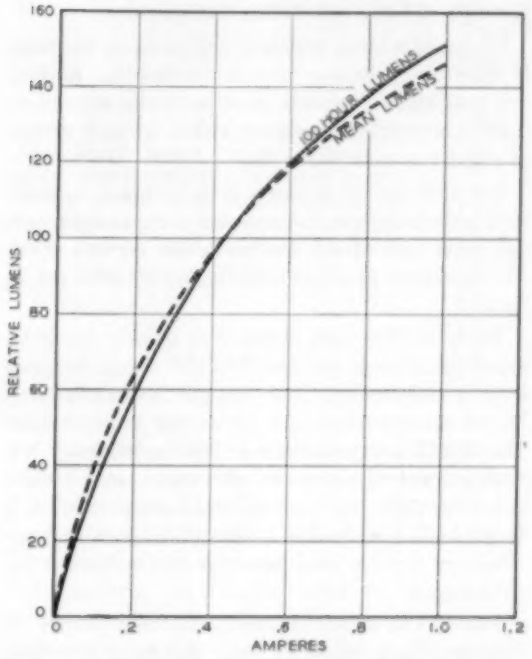

Figure 5. Initial and Mean Lumens vs. Lamp Current — 96T12 Argon-Filled Lamps. — Lumen depreciation during life is less severe at low currents but differences are not large.

practical choice for high output lamps is between instant-start and rapid-start.

Ballast size, weight, cost and losses are directly related to the ballast O.C.V. To a first approximation, ballast losses are given by the vector relationship:

$$\text{Watts loss} = K_1 \times I \times V_{oc} + K_2 \times I \times (V_{oc} - V_L) + K_3 \times I \times V_c$$

where

K_1, K_2, and K_3 = constants depending on ballast design
I = lamp current in amperes
V_{oc} = open circuit voltage required for starting
V_L = lamp operating volts
V_c = Cathode heating volts if supplementary cathode heating is used.

The first two terms are the governing factors and both increase with O.C.V. and current. It can be seen that at the higher currents required by high light output lamps, efficient ballasting will be obtained only if required O.C.V. is kept to a low value. For 96T12 lamps, required O.C.V. for rapid-start operation is roughly one-half that for instant-start, resulting in a clear-cut advantage in favor of rapid-start. At lower operating currents, the advantages of reduced O.C.V. for rapid-start may be more than offset by the cost disadvantage of equipping the ballast with cathode heating windings. Studies have shown an advantage for instant-start operation for 96T12 lamps at 0.425 ampere.

In rapid-start operation, two starting conditions must be gulfilled before the lamp can reach normal operating current:

Condition 1 — A peak voltage, sufficiently high to break down the tube and permit the flow of a milliampere or so of current, must be impressed across the lamp electrodes. The peak voltage requirement is a function of gas purity, cathode activity and temperature, type of filling gas, filling pressure, proximity of bulb wall to a conducting surface (starting aid), and the voltages between the starting aid and the lamp cathodes. If the voltage differences between lamp cathodes and the starting aid are substantially increased, by connecting an auxiliary a-c voltage source between one lamp cathode and the starting aid, the ballast O.C.V. can be lowered — considerably for short lamps, much less for long lamps.

Condition 2 — An rms voltage, higher than the maximum value of the voltage-current characteristic of the lamp, must be impressed across the lamp electrodes.[12] This requirement varies with cathode activity and temperature, type of filling gas, and filling pressure but is largely independent of gas purity, proximity to starting aid, or cathode to starting aid voltage.

If the first condition is met but not the second, the lamp glows feebly. If the second but not the first condition is gulfilled, the lamp does not light. If both conditions are fulfilled simultaneously, the lamp comes up to full current very rapidly.

The dependence of the two requirements on filling gas and filling pressure are not necessarily related. For example, while the requirement for Condition No. 1 is approximately 30 per cent higher for 96T12 krypton lamps than for similar argon lamps, the requirement for Condition No. 2 is approximately 10 per cent lower. The increased voltage requirement is one of the factors unfavorable to the use of krypton gas for high-current rapid-start lamps. Use of an auxiliary voltage is particularly helpful in reducing the ballast O.C.V. requirements for krypton lamps. But, the advantage of such an auxiliary voltage is generally more than offset by the cost and technical difficulties involved. Figure 6 shows relative starting voltages required for various diameters and arc lengths for argon-filled rapid-start lamps. The dotted sections show the effect of a 220-volt auxiliary a-c voltage between

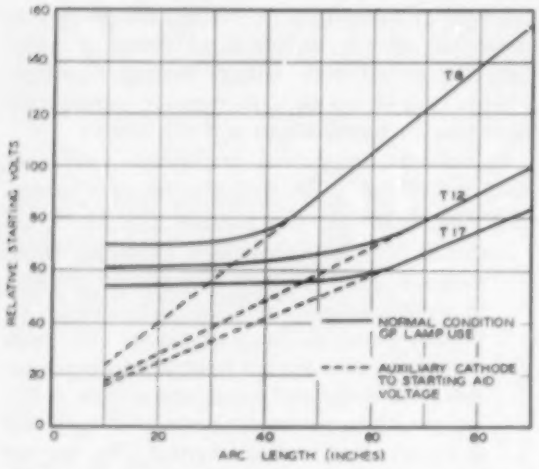

Figure 6. Lamp Starting vs. Arc Length — Argon-Filled Lamps. — Since operating voltage increases uniformly with length, short lamps normally have a high starting/operating voltage ratio. Use of auxiliary voltage can eliminate this effect but poses other problems that have prevented its use.

one lamp cathode and a nearby starting aid. The solid solid lines are for one lamp cathode connected directly to the starting aid — the prevailing condition in the field.

For length to diameter ratios less than 50 or so, starting voltages — unless an auxiliary voltage is used — is largely independent of lamp length. This is the region where the voltage requirement of Condition 1 is higher than that of Condition 2. When the line voltage is gradually increased, no conduction occurs until the voltage of Condition 1 is reached; then lamp current suddenly increases to approximately normal operating value.

For longer arc lengths, Fig. 6 shows the linear relationship between arc length and starting volts. This indicates that the voltage requirement of Condition 2 exceeds that of Condition 1. Thus, when the line voltage is gradually increased, the lamps begin to conduct a milliampere or so when the voltage of Condition 1 is reached. Little change in lamp current occurs with increasing line voltage until the voltage of Condition 2 is reached. At this point lamp current rises suddenly to approximately normal value.

Summary of Lamp and Ballast Characteristics

Choice of a lamp design is not made on the basis of superiority in any one characteristic. Rather, best over-all performance must be chosen after carefully evaluating the relative merits of each design in respect to each parameter.

For high output design it is appropriate to make such an evaluation on the basis of equal light output from each of the designs under consideration. The pertinent data for these lamps is presented in Table I.

Study of this table shows that neither the 96T8 argon-filled lamp nor the 90WT17 argon -krypton lamp is satisfactory. They are poorest in efficiency, lumen maintenance, and ballasting requirements. The 96T12 krypton lamp is best in efficiency but both current and open-circuit voltage requirements are very high. As a result this design requires a large, higher watts-loss ballast. The gain in lamp efficiency is more than offset by the ballasting disadvantages.

The 96T12 argon is clearly the best choice. It combines high efficiency with the most favorable ballasting and lumen mainenance characerisics.

Economics and Application

Lighting Economics

In the final analysis the usefulness of any lamp design depends largely upon the lighting economics it affords when used in practical fixture designs. With high output lamps, the advantages of more light must be weighed against lower lamp efficiency and the probability of greater losses due to heating effects when operated in fixtures. Measurement of heating effects is essential before lighting economics can be calculated.

Heat losses in luminaires may be readily determined after the relationship between stable and maximum light output for lamps alone is established at the conventional rating temperature, 80°F. This relationship is found by measuring light output at frequent intervals from the time the lamp is switched on until its light output becomes constant. Fig. 7 shows how light output changes as lamps warm up. The illustration is for T-12 argon filled lamps operated at 0.8 ampere. The pattern is typical but the ratio of stable to maximum light

TABLE I.—Lamp and Ballast Characteristics for Equal Light Outputs.

Lamp	Lamp Amps	Rel. Lamp Watts	Rel. Lamp Eff.	Rel. Lamp Volts	Nominal Ballast O.C.V.	Ballast Sizes & Losses	Lumen Maintenance
96T12 Argon	0.08	100	100	100	350	Satisf.	Good
96T8 Argon	1.0	115	85	103	525	Very high	Poor
96T12 Krypton	1.0	90	110	75	450	High	Good
90WT17 Argon & Krypton	2.5+	—	—	—	—	Very high	Fair

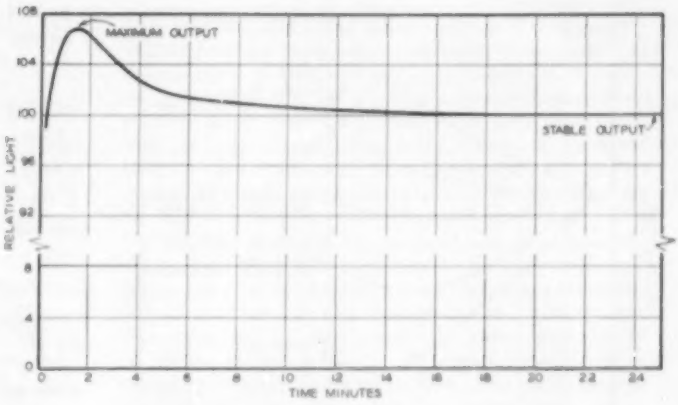

Figure 7. Light Output vs. Time — 96T12 Argon-Filled Lamps at 0.8 Ampere. — Under normal operating conditions nearly all fluorescent lamp designs operate at temperatures above the optimum. Designs vary, however, in amount of departure from maximum light output.

output is different for each lamp loading. Curve A of Fig. 8 shows how the ratio changes with current for T-12 argon-filled lamps. The departure from unity shown is due to increase in bulb-wall temperature above the optimum value.

These data, plus similar data for lamp-fixture combinations, permit the evaluation of light losses due to the heating effect of fixtures. The ratio of stable to maximum light output for a specific lamp-fixture combination is compared with the ratio for bare lamps operated at the same current. Any difference is due to the heating effect of the fixture.

Curve B of Fig. 8 shows the results of such a test made with 96T12 argon-filled lamps in a typical closed-end, open-top, industrial lighting fixture. The upward light componeot of the fixture tested was 27 per cent. Comparing Curve B with bare lamp performance (Curve A) shows that additional losses due to heat are small when well ventilated fixtures are used.

Since high-output lamps would often be used in well-ventilated fixtures, it is appropriate to analyze costs on that basis. Fig. 9 shows the results of such a cost analysis using the Barr-Amick[15] method. It is based on instant-start operation at 0.425 ampere; rapid-start operation at 0.6, 0.8, and 1.0 ampere.

Curve E of the drawing shows the favorable effect of higher output-per-lamp on initial cost. It also indicates that there are limiting factors. A point is reached where cost begins to rise because light output is increasing relatively slowly while both heating effects and the reduction of lumen maintenance are becoming greater.

Curve C shows that operating costs at 0.8 ampere may also be lower than for conventional 0.425-ampere operation; but only slightly and only under favorable conditions — relatively short burning and low energy rate. This is because the savings in lamp and maintenance costs resulting from the use of fewer high-output lamps more than offset the increased energy cost inherent to their lower efficiency.

With higher electric rates or longer burning hours, increased energy costs will usually outweigh the lamp and maintenance savings and operating costs will be greater for high-out lamps. For the extreme conditions illustrated by Curve A, operat-

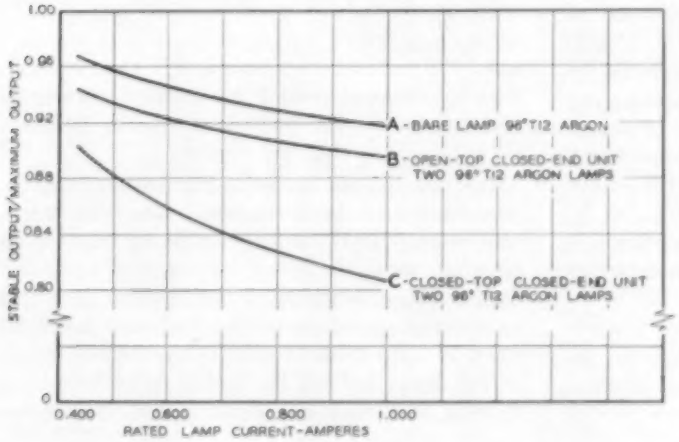
A - BARE LAMP 96"T12 ARGON
B - OPEN-TOP CLOSED-END UNIT TWO 96" T12 ARGON LAMPS
C - CLOSED-TOP CLOSED-END UNIT TWO 96" T12 ARGON LAMPS
STABLE OUTPUT/MAXIMUM OUTPUT
RATED LAMP CURRENT-AMPERES

Figure 8. Effect of Lamp Current and Enclosure on Ratio of Stable to Maximum Light Output. — Higher lamp current and enclosure in fixtures both increase lamp temperature and, therefore, increase light fall-off. Use of well-ventilated fixture minimizes losses.

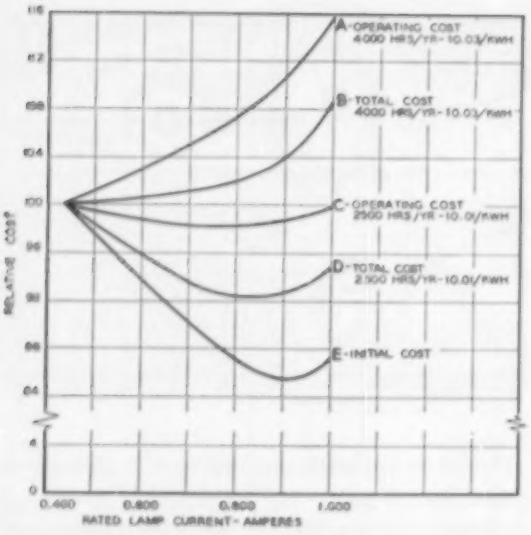

Figure 9. Lighting Costs vs. Lamp Current — Two 96T12 Argon-Filled Lamps in Well-Ventilated Fixture. — Proper choice of higher current can substantially reduce initial lighting costs. Operating and total costs may also be lower for many common operating conditions.

ing costs for 0.8 ampere rapid-start lamps are about 7 per cent higher than for 0.425-ampere operation.

Curves B and D show relative total annual costs for the two operating conditions. This provides the best basis for over-all comparison. The curves are arrived at by combining annual operating cost with 15 per cent of the appropriate initial costs. They indicate that 0.8-ampere high-output design can offer substantial savings (8 per cent) for common favorable operating conditions (curve D). Even under unusually unfavorable conditions (curve B) the relatively small increase in total cost, 2 per cent, may be acceptable in view of the reduction in initial investment costs.

The economics of high-output will be poorer when the lamps are used in less favorable fixture designs. Curve C of Fig. 8 shows that losses in light due to heating effects are greater when closed-top, closed-end, industrial luminaires are used. It should be noted that light losses due to fixture heating are never accompanied by equal reduction in efficiency. This is because the increased lamp temperature, which reduces light output, also reduces lamp wattage. Consequently, in general, the change in lumens-per-watt efficiency due to heating effects in fixtures is only about half as great as the reduction in light output.

Table II summarizes the results of cost analysis for closed-top, closed-end industrial luminaries using 96T12 argon-filled rapid-start lamps operated at 0.8 ampere. The increase in costs compared with

TABLE II.—Comparative Costs—96T12 Argon-Filled Lamps, Closed-Top, Closed-End Industrial Fixtures. 0.8-Ampere Rapid-Start Operation Relative to 0.425-Ampere Instant-Start Operation.

Energy Rate per KWH	Relative Initial Cost	Burning Hours per Lamp	Relative Operating Cost	Relative Annual Cost
1¢	94⅛	2500	105⅛	99⅛
3¢	94⅛	4000	114	109

the opentop units is in almost direct proportion to reduction in lamp efficiency due to increased heating effects.

Applications

In many situations the requirement that lighting be concentrated at particular areas limits the number of fixtures that can be installed; for example, store counters or other merchandising areas. Here, use of high-output lamps will permit needed higher illumination levels in those areas. Similarly, high-output lamps will permit increases in illumination levels in the many applications where additional fixtures cannot be installed because of appearance or space limitations. Luminous indirect lighting, coves, and show windows are examples of this situation. Since lamp brightness is higher with high output lamps, extra care must be exercised in selecting fixture types for those installations where comfort is a primary consideration.

In Deluxe colors high-output lamps can produce as much or more light than 0.425 ampere lamps in standard colors. Thus, they will be useful in color-critical applications where they can provide both good color rendition and high illumination levels.

Outdoor applications are another promising field for high-output lamps. Severe reduction of light output at low temperature has been a problem here, and the higher bulb-wall temperature of high-output lamps minimizes or eliminates this effect. Studies of lamp performance in fluorescent street lighting luminaires[16] show that 1.0 ampere T12 argon-filled lamps can actually deliver approximately 30 per cent more light at 0°F than at 80°F. Higher voltage is needed for reliable starting at low temperatures, so ballasts specifically designed for outdoor operation are needed.

The factors unfavorable to high-output lamp design have now been resolved. Excellent lumen maintenance and efficient ballasting have been achieved, while the trend toward well ventilated fixture design continues to grow. The advent of such lamps can have widespread and beneficial effect on many fields of lighting application. High-output lamps increase the usefulness of fluorescent lighting and, more important, provide the oppor-

tunity to achieve the higher illumination levels needed in so many applications.

Acknowledgments

Much of the data presented here resulted from work done by other engineers. Particular thanks are due to L. F. Kramel and R. N. Thayer of the Lamp Development Laboratory, and to W. R. Stephens, Photometric Laboratory, Application Engineering Department, General Electric Company.

References

1. E. F. Lowry, W. S. Frohack, G. A. Myers: "Some Fluorescent Lamp Parameters and Their Effect on Lamp Performance," ILLUMINATING ENGINEERING, Vol. 41, 859 (1946).
2. R. J. Diefenthaler and J. C. Forbes: "Effect of External Factors on Light Output of Fluorescent Sources," ILLUMINATING ENGINEERING, Vol. 41, 872 (1946).
3. G. E. Inman and R. N. Thayer: "Low Voltage Fluorescent Lamps," *Electrical Engineering*, Vol. 57, 245 (1938).
4. R. N. Thayer and B. T. Barnes: "The Basis of High Efficiency in Fluorescent Lamps," Journal of the Optical Society of America, Vol. 29, 131 (1939).
5. J. W. Marden, N. C. Beese, and G. Meister: "Effect of Temperature on Fluorescent Lamps," *Transactions* I.E.S., Vol. 35, 55 (1939).
6. J. W. Marden, N. C. Beese, and G. Meister: "Operating Temperatures of Vapor Lamps," *Journal of the Optical Society of America*, Vol. 30, 184 (1940).
7. G. S. Evans: "Low Temperature Performance of Krypton Filled Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. 45, 175 (1950).
8. C. M. Holden: "Effect of Ambient Temperature on Light Output of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. 48, 645 (1953).
9. C. W. Jerome: "Effect of Temperature on Electrical and Color Parameters of 40T12 Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. 48, 478 (1953).
10. C. G. Found and W. J. Winninghoff: "Comparison of Argon and Krypton as a Filling Gas in Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. 44, 161 (1949).
11. D. D. Hinman, R. L. Keiffer, and C. E. Strecker: "Fluorescent Lamp Performance on Sequence Start Ballasts," ILLUMINATING ENGINEERING, Vol. 46, 560 (1951).
12. W. C. Gungle: "Electrical Characteristics of Lamps and Ballasts," ILLUMINATING ENGINEERING, Vol. 48, 579 (1952).
13. J. W. Marden and G. Meister: "Electrical Characteristics of Low Pressure Discharge," *Transactions* I.E.S., Vol. 24, 1095 (1939).
14. R. N. Thayer: "Determinants of Fluorescent Lamp Life," ILLUMINATING ENGINEERING, Vol. XLIX, p. 527 (1954).
15. A. C. Barr and C. L. Amick: "Fundamentals of Lighting Cost Analysis," ILLUMINATING ENGINEERING, Vol. 47, 260 (1952).
16. J. E. Bock and J. S. Franklin: "Effect of Temperature on Fluorescent Street Lighting Luminaries," ILLUMINATING ENGINEERING, 49, 110 (1954).

DISCUSSION

A. G. PENNY:* I would confirm the remarks made by Dr. Lowry (November ILLUMINATING ENGINEERING) in his paper that T12 fluorescent tubes loaded to around 1 ampere do not constitute a novelty. As Dr. Strange mentioned, T12 lamps running at 850 milliamperes are the normal type in England.

In addition to the popular 60-inch 80-watt, we have also a 24-inch 40-watt and some makers have for several years been making a 96-inch T12 argon-filled tube running at 125 watts; the electrical characteristics are, approximately, 150 tube volts at 850 milliamperes running current. In our "Natural" color (which corresponds to the American cool white deluxe) it gives around 6700 lumens at 100 hours.

H. U. HJERMSTAD:** The authors have very clearly demonstrated that the ballast size, weight, cost, etc., are directly related to the open circuit ballast voltage:

(1) I don't agree that the advantage is for an instant start ballast for the 96T12 lamps at 425 ma. (See page 9.) This may be true for a single lamp but for operation where lamps can be operated in series, as a sequence-start device, the advantage of a 96T12 lamp at 425 ma is just as practical as it is for the present 48T12 rapid start lamp. This would be especially true if the cathode of the 96T12 lamp for a 425 ma lamp were identical to that of the present 48T12 rapid start lamp. The present cathode for the 800 ma operation requires more va than is necessary for this lower operating current.

I personally feel that there is a greater need for a companion rapid start lamp at 425 ma than one required for 800 ma operation. The va requirements of the ballast can be considerably less for a rapid start system than that of an instant start system. At the present time the lamp-ballast specifications require at least 100 ma (through a specified resistance representing a dummy lamp load). Whereas, in the case of the rapid start system, very low current (1 to 5 ma) is all that is necessary to break down the tube. The starting difficulties of the instant start system have been overcome by continuously heating the cathodes. Circuit-wise, the system becomes exactly what is available in the 40-watt sequence start ballast circuits. The problem of open circuit voltages for the rapid start type of circuit has been met with the socket and base connection presently used for the high current lamps.

(2) I wish that the authors would elaborate and describe more fully Conditions 1 and 2 (on page 9) which must be fulfilled for rapid start operation.

(3) To date we have found the interest in the 72T12 and the 96T12 rapid start high current lamp has primarily come from people whose activity requires a light source for outdoor use. Under these circumstances, the open circuit voltage required for starting must be increased materially in order to insure proper starting under cold weather conditions. Will the authors state the necessary open circuit voltages required for these lamps at +30 F, zero and −20 F?

(4) It has been our experience that if sufficient open circuit voltages are supplied to insure stable starting conditions for low temperature operation that the lamps will instant start most every time under normal room temperatures. Since this is the condition that exists most of the time in a practical application of these lamps, what is the expected lamp life under these conditions?

(5) The present lamp holders for the 96T12 lamp are rated for 600-volt operation. In order to insure proper starting characteristics of the 96T12 lamp for outdoor use, the open circuit voltage will have to exceed 600 volts. Are there any lamp holders available that would permit circuitry of voltage higher than 600 volts?

M. PENNYBACKER:* All fluorescent lamps operating in excess of an optimum current sacrifice efficiency and lumen maintenance. These higher currents usually introduce also greater ballast problems and pose a threat to lighting quality because of the glare associated with high output sources. Comparisons with the optimum have not been emphasized by the authors in their interesting and well presented paper, so I should like to touch briefly on these four factors.

(1) *Lamp efficiency.* In Dr. E. F. Lowry's paper (November ILLUMINATING ENGINEERING) Fig. 5, Curve C, shows that with standard 96T12 lamps, argon-filled, the efficiency drops from approximately 68 lumens per watt at 250 ma to

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**Sola Electric Co., Chicago, Ill.

*Voltarc Tubes, Inc., Norwalk, Conn.

67 at 425 ma and to 63 lumens per watt at 800 ma. (Unfortunately he did not show the optimum current or efficiency for T8 lamps, but I have found the current to be less than 200 ma.) It appears that the factor of lamp efficiency is reduced by about 5 lumens per watt, or 7 per cent due to using 800 ma.

In the above calculation it should be noted that only the current is varied. The efficiency at each of the currents could be improved by using krypton in the fill gas, but their relative efficiencies would remain substantially unchanged. At any rate, these differences in efficiency at 100 hours' life are minor compared to the large differences that develop during life, which I will mention next.

(2) *Lumen maintenance.* Light depreciation is at a rate proportional to watts in the positive column per unit area of phosphor. The relatively rapid depreciation of all lamps operating above optimum currents can be judged from the following: if the ratio of positive column watts per unit area of a T8 bulb operating at 120 ma is taken as 100 per cent, then the corresponding ratio for T12 lamps at 425 ma is 126 per cent and for T12 lamps at 800 ma it is 162 per cent. In other words, the phosphor in the latter lamp will depreciate at a rate about 62 per cent faster than in a standard cold cathode lamp.

For this calculation I have taken commercial lamps, using 43 total lamp watts for the standard 96T8 cold cathode lamp filled to 4.5 mm. argon; 74 watts for the standard 96T12, argon filled, 425 ma lamp; and 100 watts for the high output 96T12, 50-argon, 50-krypton filled. The corresponding watts losses at the electrodes have been calculated at 10.2 watts, 8.1 watts, and 15.2 watts, respectively. These latter are subject to some variation with different methods of measurement, but they are believed to be proportional, regardless of which method of measurement is used. Note, however, that here I have given the high output lamp the benefit of krypton in the fill. Its wattage, and hence its rate of lumen depreciation relative to the other lamps, would be still greater if it were filled with argon the same as the others.

(3) *Ballast efficiency and cost.* In Table I, the authors show a comparison of "Ballast Sizes and Losses" for various high output lamps, but unfortunately they do not compare them with ballasts for low or medium output lamps. From their approximate formula for watts loss in the ballast, it is apparent that the more the term (lamp operating voltage), the greater the losses and the greater the ballast size, weight, and cost. As operating currents go up, the lamp operating voltage goes down, hence the lower the ballast efficiency. It should be noted also that krypton in the fill still further reduces ballast efficiency.

(4) With regard to quality at the light source, I wonder if the authors would be good enough to give us the relative surface brightness of standard T12 lamps operating at optimum current, 425 ma and 800 ma.

W. C. Gundle:* We were pleased to note that in the verbal presentation of this paper at the Sources Session at Atlantic City, New Jersey; the authors reported more recent studies on high output lamps using a mixture of argon and krypton at low pressures as a fill gas. These results corroborated studies as reported by Dr. Lowry in an earlier paper at this session to the effect that the optimum design of a high output lamp has a 96T12 bulb using a mixture of argon and krypton at low pressures as a filling gas.

The effect of fixture design on the light output of a lamp cannot be overstressed. The design dictates the ambient temperature in the neighborhood of the lamps. It is a well known fact that the light output of a lamp peaks at about 70F and falls off with both increasing and decreasing temperatures. Thus with high output lamps, which by their very nature generate more heat than regular lamps (0.425 ampere operation), special care needs to be taken in designing the fixture so that maximum cooling will be obtained.

We agree that a series rapid start type ballasting circuit will give the best overall performance. This type of circuitry eliminates the starter used with standard start circuits and reduces the necessary open circuit voltage used with instant circuits.

J. W. Strange:* This paper on "High Loading Lamps" is very interesting to us in England because the lamps referred to have a loading very similar to our most popular lamp size 80-watt 60-inch T12 lamp which normally operated at a current of 0.85. During the early years of operation of this lamp we fully appreciated that it was overloaded and in consequence the initial efficiency was about 6 per cent down on the 40-watt lamp and the maintenance curve was appreciably worse. During recent years, however, with the improvement of phosphors and of lamp processing, the relative position of the 80-watt to that of the 40-watt has steadily improved. This can be illustrated by making use of the Lowry equation. The different processes of this equation for the 80-watt lamp have larger exponents and therefore reach completion sooner but their magnitude is little different from that of the 40-watt lamp. We have used this equation with considerable interest for a number of years and can report excellent agreement with the general conclusions put forward by Dr. Lowry.

The relative economic advantages of the 80-watt to the 40-watt are difficult to summarize because they are obviously subject to a number of factors. The best general answer is provided by customer reaction to the two types. Admittedly the 80-watt had a good start in English usage but since the 40-watt became available with its higher efficiency the 80-watt has remained by far the most popular for offices, factories, shops, etc. When the cost of fixtures is taken into consideration the overall cost of providing light from a high loading lamp of the 80-watt type is appreciably better than the alternative of the low loading lamp.

In investigating the use of krypton for these lamps we came across one major difficulty, the considerably worse starting characteristics of the krypton lamps on cathode heating transformer types of circuit. This we attributed to the excitation energy of the krypton in the discharge not being sufficient to cause ionization of the mercury and failing therefore to contribute to the conductivity of the discharge. This point may of course be met by the use of krypton-argon mixtures at lower pressures as suggested in Dr. Lowry's paper without any serious reduction in lamp life.

A. C. Barr and W. J. Karash:** We wish to thank the discussors for their comments and interest. The comments of Messrs. Strange and Penny regarding the popularity and widespread usage of high-output F-lamps in England augurs well for the acceptance of high-output design in this country.

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*Thorn Electrical Industries Ltd., Highgate, England.
**Authors.

In reply to Mr. Hjermstad:

(1) We wish to point out that our cost-of-lighting analyses for 8-foot T12 lamps at 0.425 amperes included estimates of ballast costs and losses. Using the data furnished us, there was slight advantage for instant-start operation. It is of course possible that newer ballast data will show an advantage for rapid-start operation. We would welcome additional data on ballast costs and losses for the two methods of operation.

(2) Condition 1 involves initial ionization of the lamp. The voltage required to produce initial ionization can often be reduced by use of a spark coil, introduction of transients into the circuit, or placing a strong a-c field between one lamp cathode and a near-by starting aid.

At very low currents, the volt-ampere characteristic of a fluorescent lamp has a positive slope. At higher currents, of course, the slope is negative. The requirement of Condition 2 is that the rms voltage delivered by the ballast must exceed the maximum value of the volt-ampere characteristic of the lamp. The voltage requirement of Condition 2 increases directly with arc length and decreases somewhat with increased cathode activity.

The voltage requirements for the two conditions are largely independent of each other. In single-lamp or lead-lag operation using conventional circuits, especially for short lamps or krypton-filled lamps, the voltage required to fulfill Condition 1 usually exceeds that required to fulfill Condition 2. If the requirement for Condition 1 could be lowered, by use of a strong a-c field between one lamp cathode and the starting aid for instance, then the required ballast open circuit voltage could be reduced. This of course would reduce ballast size, cost and losses.

In two-lamp series operation, the entire open circuit voltage is impressed first across one lamp. Transients introduced in the circuit by the small current flowing through the first lamp in series with the bypass capacitor are usually sufficient to produce ionization of the second lamp. Consequently the limitations on two-lamp series ballast design are usually imposed by the rms voltage requirements of Condition 2.

Two-lamp series operation is especially advantageous for short lamps, for krypton-filled lamps, and for lamps and circuits where the ballast voltage required to fulfill Condition 1 greatly exceeds the ballast voltage required to fulfill Condition 2.

(3) We are currently completing an investigation of voltages required to start lamps at low ambient temperatures. We anticipate that starting voltage requirements for the two lamps mentioned, as well as for other lamps, will be released through the usual channels in the near future.

(4) Use of low temperature, high voltage, conventional rapid-start ballasts at normal temperatures will result in instant starting and some reduction in lamp life. The degree of reduction in lamp life will depend on the frequency of starting. As yet insufficient life data are available to state a figure for lamp life under these operating conditions. Limited data indicate that the problem is less serious with series than with multiple operation. However, in as much as the cathodes of rapid-start lamps are somewhat similar to cathodes designed for instant-start operation, and since outdoor operation usually involves infrequent starting, we do not feel that the reduction in lamp life will be serious. This is confirmed by our experience with fluorescent street lighting installations.

(5) We know of no lampholders rated in excess of 600 volts. We are currently working with circuit and lampholder combinations which we hope will provide a solution to the very real problem. Until a solution is available, it will be necessary to provide the customary circuit disconnects or interlocks.

In reply to Mr. Pennybacker:

(1) Our data, Fig. 4, confirm Mr. Pennybacker's comment that the maximum efficiency for T8 lamps occurs at currents below 200 ma. While use of krypton at a given current increases lamp efficiency, it also reduces light output (Fig. 1). The increase in lamp current required to restore light output reduces both lamp and system efficiency.

(2) Lumen maintenance, as plainly shown in Fig. 5, decreases with increased lamp loading. As shown in Fig. 5 and pointed out in the text, the lumen maintenance of 800 ma T12 lamps is only some 3 per cent less than for similar lamps at 425 ma. When this relatively small difference in lumen maintenance is weighed against the advantage of much higher output per lamp, it becomes apparent that the high-output design has wide application.

As repeatedly pointed out in the paper, lighting economic analyses involve many factors beside lamp efficiency. When all these factors are taken into account, high-output fluorescent lamps offer definite advantages in many applications.

(3) While Mr. Pennybacker's comments on ballasting are generally true, it should be pointed out that the lower ballast efficiency experienced with multiple operation of krypton lamps is usually eliminated by use of series ballasts.

As pointed out in the paper, reducing lamp current reduces ballast size, cost, and losses and also reduces light output. The important point to be kept in mind is the overall cost of providing a given degree of illumination.

(4) Mr. Pennybacker raises the question of surface brightness of high-output F-lamps. As pointed out in the text, the higher brightness of high-output lamps necessitates that extra care be exercised in selecting fixture types for those installations where comfort is a primary consideration. Economic studies indicate that it is almost always far more economical to control glare by proper fixture design than by use of much greater numbers of low brightness lamps, which still require shielding in most applications.

The current published value for surface brightness of standard cool white T12 lamps at 425 ma is 1850 footlamberts. Using this value and Fig. 1, we obtain approximately 2550 footlamberts at 800 ma.

Presumably Mr. Gungle means that the light output of a 425 ma T12 fluorescent lamp peaks at 70 F ambient. Our data and experience show that F-lamps deliver maximum light output at bulb wall temperatures in the vicinity of 100 F. The relationship between bulb wall temperature and ambient temperature depends, of course, upon lamp loading and lamp ventilation.

Our experience with krypton-filled lamps confirms in part Mr. Strange's observation. For single-lamp or lead-lag operation, use of krypton usually increases lamp starting volts. For two-lamp series operation, use of krypton or argon-krypton mixtures may result in a decrease in required ballast open circuit voltage.

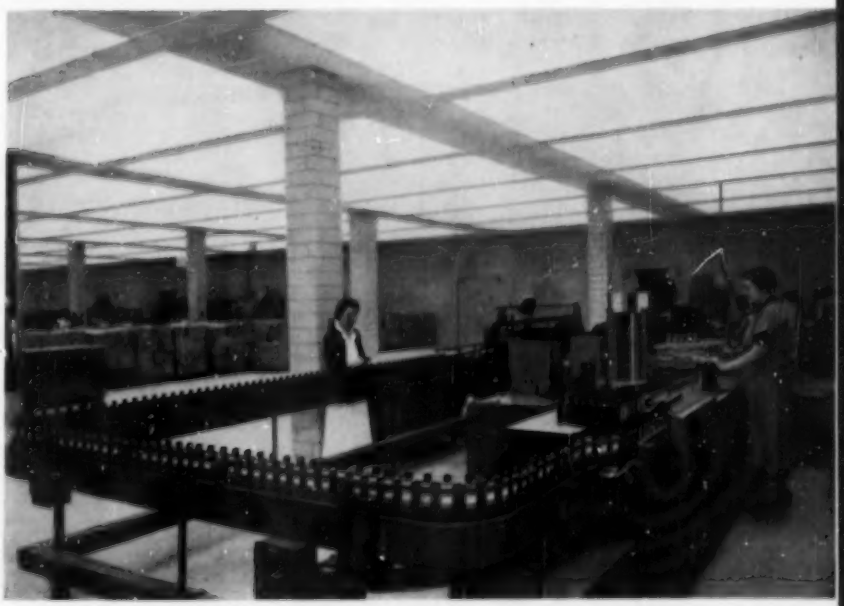
In the nearly four years since May 1951 when an article was published in I.E. entitled "Quality — Our Next Step in Industrial Lighting," quality lighting in industry has become an accepted goal. Many current installations conform with, or better, the recommendations in the American Standard Practice of Industrial Lighting, with regard to upward light, brightness ratios, surface reflectances and other quality features.

Upward component of 61 per cent of total light output is one of the quality features of the installation converting an old grocery warehouse into the production areas of the Sayers Printing Co., in St. Louis. The direct-indirect luminaires, using deluxe lamps, provided 59 footcandles after four months' operation. Other factors contributing to a good seeing environment are the light-colored floor and acoustic tile ceiling and the shielding of luminaires with louvers. Lighting equipment was specified by H. J. Poehling, of City Sales Inc., St. Louis, and was installed by the Electric Service Co.

Narrow-beam incandescent and concentrating beam mercury units are staggered on 17 x 19-foot centers for improved color rendition, in the machining area of Minneapolis Moline Power Implement Co. The vapor-proof units are mounted at a height of 36 feet and, after six months' operation, provide 28 footcandles. Photo courtesy of Benjamin Electric Mfg. Co.

Close attention was paid to brightnesses and surface reflectances in the re-lighting of McCormick & Co.'s Baltimore plant. In the spice-packing room shown here, the flat white ceiling has a brightness of from 30 to 70 ft-L; light canary yellow walls with light gray dado, 10 to 12 ft-L; the gray floor (since redone in blue and white tile), 13 ft-L. Brightnesses of machines are from 7 to 10 ft-L. The 2-lamp louvered-bottom luminaires direct 40 per cent of the illumination upward to the white ceiling, which is 12 feet high, with fixtures suspended approximately 30 inches. There are 210 of these units in the area of 100 by 125 feet. H. M. White of Consolidated Gas Electric Light and Power Co. of Baltimore, was lighting engineer.

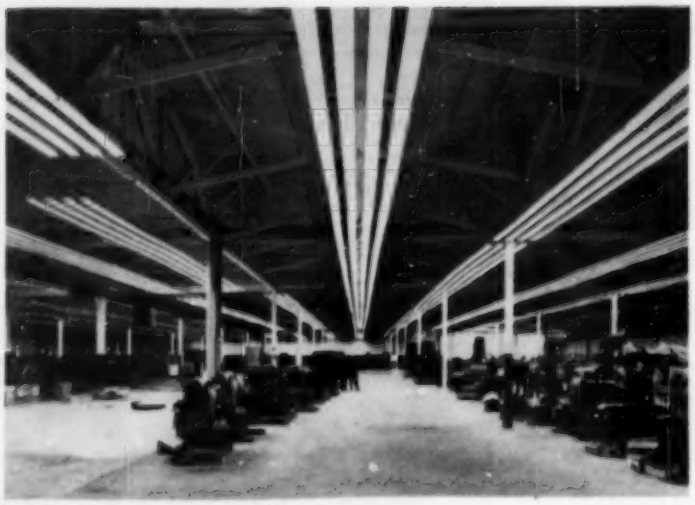
Quality—
A Big Step in Industrial Lighting



Egg-crate luminous ceiling plus light finishes plus air conditioning are demonstrated in this bottling line area of the Mennon Company plant in Morristown, N. J. Here bottles are cleaned, filled, capped, labeled and cartoned. The white metal egg-crate louvers in the ceiling are arranged in 4 x 2-foot panels and provide 45/45 shielding. Architects were A. M. Kinney Associates, Cincinnati; electrical contractor Edward J. White Co., Newark, N. J.

Grid system was chosen for good overall general illumination, particularly on vertical surfaces, in McDonnell Aircraft Corp., Robertson, Mo., for final test and modification of finished aircraft. One area, with a 40-foot ceiling, uses 3-lamp open-end porcelain-enamel reflectors with 96-inch T12 lamps on 430 ma; and another similar area, with a 30-foot ceiling height, has 3-lamp units in one direction and 2-lamp units in the other. Both areas are 200 x 200 feet and have concrete floors with reflectance of 55 per cent. Engineers and architects were Sverdrup and Parcel, Inc., St. Louis.

Especially designed for large areas, such as this aircraft plant of Northrop Aircraft, Inc., Anaheim, Calif., these industrial luminaires are mounted in continuous rows for the entire length of the 400-foot building. Each unit contains four lamps, on 12-inch centers, each lamp having its individual low-brightness aluminum reflector. The luminaires are mounted 12 feet above the floor on 12½-foot centers providing 90 footcandles illumination after six months' operation. Installation by William P. Neil Construction Co.; photo courtesy Supreme Lighting Co., Los Angeles.



High-bay installation in another Northrop Aircraft plant, in Hawthorne, Calif., uses a total of 274 400-watt J-H1 mercury lamps, with high-bay ventilated reflectors. Ventilating slots in the units are used to create chimney effect to cut down on dust accumulation. Providing 35 footcandles in service, the units are spaced on 20 x 12½-foot centers at 30-foot mounting height. Plane in the foreground is a Northrop Scorpion F-89, a USAF all-weather interceptor. Photo courtesy of Westinghouse Electric Corp.

Electric Discharge Lamps In Street Lighting Service

By JOHN W. YOUNG

THE USE of electric discharge light sources in street lighting service presents factors in application and operation not involved with the filament lamp. Such lamps, however, are well adaptable to street lighting and moreover possess certain distinctive light production assets not readily available with the incandescent type.

In 1933, the sodium lamp was introduced as a companion light source to the generally used incandescent. It marks the first challenge to the incandescent lamp since the latter had virtually superseded gas and arc lighting. Several mercury vapor installations were made about the same time. While World War II interrupted normal growth, a decided trend toward mercury lamps has been noticeable in the last five years with very little expansion of sodium vapor usage. Recently some real effort has been directed to the application of fluorescent lamps as a light source in this same field.

All three sources have in common the property of high efficiency; that is, the generation of two to three times the lumens per watt of that of incandescent, as illustrated in Fig. 1. A second particular property of vapor lamps is their long useful life. The color quality of sodium and mercury is a feature which gives rise to special considerations. Concurrently with the introduction of electric discharge lamps and the progress in illuminating engineering, there has developed an increasing demand by those applying street lighting for more specific data on lamp performance, including performance in the luminaire designed for the particular lamp used.

Industry-wise the current evaluation of light source development might be summed up as follows: any major change in filament lamp characteristics is not in view at the present time; sodium seems to have reached the region of optimum status; the mercury lamp field possesses potentials in development that are highly challenging to the lamp and luminaire designer; fluorescent lamps merit intensive study and adequate trial.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 13-17, 1954, Atlantic City, New Jersey. AUTHOR: Lighting Engineer of the New England Electric System, Boston, Massachusetts.

Thus, as shown in Fig. 2, the field of available light sources and sizes has widened appreciably.

There exists a measure of reluctance, no doubt, on the part of some prospective users to modify the long established practices with filament lamps. But of note is the progress already made throughout the industry in dealing with the new light sources on the basis of more efficient illuminants, operating in the superior light distributing devices available today, and adjusting operating methods and revising commercial procedure when necessary.

Accordingly, it is the purpose of this paper to stimulate thought and discussion on the course of vapor lamp lighting. Features of commercially used lamps are considered and application practice reviewed. The material includes various data and operating experience of the utility with which the author is connected.

Mercury Vapor Lamps

Mercury vapor lamp installations for the country have reached an impressive total, and this source is currently under steady expansion. Lamp units of all sizes now in service in the States have been reported as of early 1954 to total 250,000.[1] In the author's utility company, the approximately 9000 mercury units represent a block of lumens greater than all other lamps 2500 lumens and above combined.

Even though mercury vapor has been and is growing actively, it should be recognized that it is a new light source development. Though virtually identical lamps are used widely in interior lighting in industry, these lamps have not had the exhaustive laboratory experience or universal service experience in street lighting comparable to that of the filament lamp. But to the user of several years' standing, marked progress in quality of lamps and performance is clearly apparent.[2,3,4]

Lamp Characteristics

As is generally understood, auxiliary apparatus such as the transformer ballast must be used to transform voltage and also limit the current to the lamp due to the negative resistance characteristic of electric discharge lamps.[5]

Mercury lamps have several significant features:

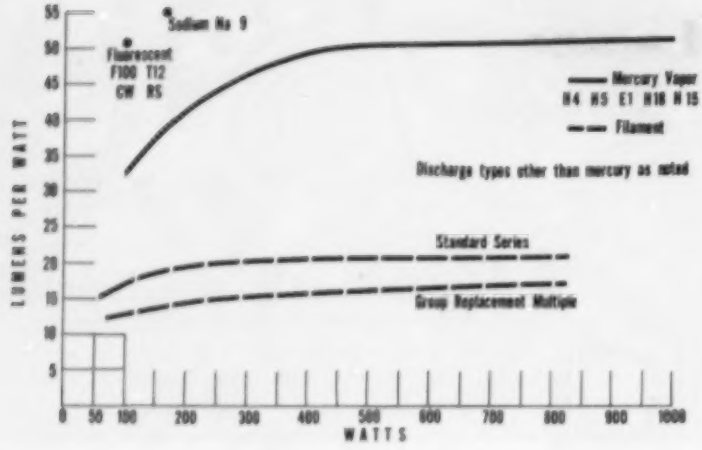


Figure 1. Illustrating lamp efficiency as a function of lamp watts — commercially used street light lamps. In this comparison, filament lamp types were selected to show the widest possible range of filament lamp efficiencies; their relationship is not intended to indicate any advantage of either type over the other.

of primary note is lamp efficiency, ranging from 33 to 50 lumens per watt, a sizable increase compared with the range of 14 to 21 lumens per watt for incandescent. Also of importance is the inherently long and useful life, average rated life values varying from 4000 to 6000 hours for lamps 250 watts and above. Color is a distinctive attribute. Lamps will start and maintain satisfactory lumen output at temperatures down to −20°F and in some cases somewhat lower. The exact figure is related to ballast type. Light output during life drops at a somewhat sharper rate than with the larger incandescent lamps. Detail consideration of certain of these points will be covered in the appropriate following section.

An operating requirement peculiar to the mercury lamp is that of the warm-up period to full intensity. Starting wattage characteristics of the 400-watt low- and high-pressure lamps are given in Fig. 3. These curves are from a series of tests of various lamps and ballasts and simulate field conditions of the lamp and luminaire installation.

Lamp Designations and Initial Lumen Rating

Mercury lamp sizes have been growing in numbers, and the lamps that are now recommended for street lighting are given in Table I.

Since a new lamp experiences rather rapid decrease of light output during the first hours of life, the rated initial lumens are established after 100 hours of burning.

Furthermore, such rated lamp values apply as the average of a group of lamps, as variations in fabrication in individual lamps must be expected. The matter of lumen output tolerances in mercury lamps is under constant improvement by the lamp manufacturers. Uniform tolerances have not been established in the industry, since the "standard" lamp has yet to be specified as to complete physical and electrical characteristics. A further factor is

Figure 2. Nominal lamp sizes (initial lumens). Filament lamp sizes are those listed in the E.E.I.-N.E.M.A. Standards for Filament Lamps used in Street and Highway Lighting, E.E.I. Pub. No. TDJ-131; N.E.M.A. Pub. No. 118-1951 January 1951.

RANGE IN LUMENS	Lamps Used in Street Lighting Service Filament and Electric Discharge Types			
	FILAMENT	MERCURY VAPOR*	FLUORESCENT	SODIUM
1,000	1,000			
	2,500	3,300**		
5,000	4,000		5,250 (at 80°F)	
10,000	10,000	11,000		10,000
15,000	15,000	15,000		
20,000		20,000		
25,000				
30,000				
35,000		35,000**		

50,000				
55,000		55,000**		
60,000				

* Vertical Burning Position
** Limited Experience or Proposed

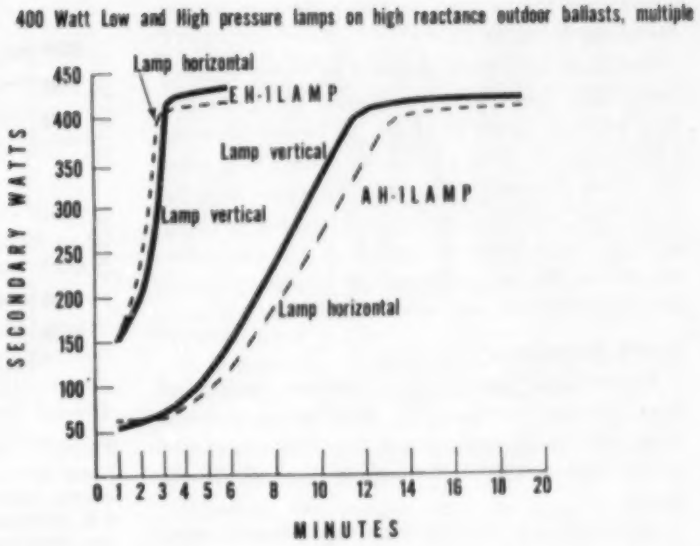


Figure 3. Typical warm-up cycles. Each curve, EI "high-pressure," and AI "low-pressure" lamp is the average of a series of tests using random combinations of five multiple ballasts, (four manufacturers) and six lamps (two manufacturers). Lamp types — EI BT 37 bulb, AI T-16 and BT 24 bulb.

the lamp auxiliary and its variation in design operating characteristics.

In an investigation within the author's utility company of lamp and ballast wattage variations, lamps and ballasts were taken at random from stock supplies of such equipment. The results of groups of the 400-watt type, indicate that an objective in lamp-and-ballast tolerances might be considered suitable if consumed lamp wattage was ±7½ per cent of 400 watts.

Of the approximately 9000 mercury lamps in the utility company system, the 400-watt AH1 and EH1 constitute the high percentage of installations, the remainder being the 250-watt size. Since no specific demands have been encountered for corrected color, installations of the JH1 lamp have not been made. The sum total of lamp experience is, therefore, as throughout the industry, with the 400-watt and 250-watt sizes. Feasible lighting layouts using the 700-watt lamp, as employed notably in the Atlantic City Boardwalk relighting, have been determined for large traffic rotary and plaza areas. Experiments have been carried out with the 100-watt lamp but conclusive data have not been obtained to date.

TABLE I.—Lamp Designations and Initial Lumen Output for Lamps Recommended for Street Lighting Service.

Lamp Watts	Lamp Designation	Initial Lumens Vertical Burning Position
	Clear Mercury	
1000	H1000 — A15 or AH15	52,000-55,000
700	— AH18	35,000
700	*H1000 — A15	35,000
400	H400 — E1 or EH1	20,000
400	H400 — A1 or AH1	15,000
250	H250 — A5 or AH5 H250 — C5 or CH5	11,000
100	H100 — A4 or AH4	3,300
100	K100 — K4 or KH4	3,300
	Fluorescent Mercury	
1000	H1000 — C15 —	46,000
1000	— BH15	49,000
700	*H1000 — C15 —	31,500
700	— BH18	33,000
400	H400 — J1 or JH1	17,000-19,000

*Operating on a ballast furnishing 700 watts to the lamp.

Essential Lamp Design Characteristics

The fundamental mercury lamp characteristics besides the approximate lamp watts are: 1) Efficiency, with lamp burning position stated; 2) Life, specified as the rated average life in hours on a burning cycle of 10 hours per start; 3) Lumen maintenance which is the mean or average lumens during rated life. These data are the essentials required by the application engineer in effecting his lighting design.

Efficiency

The improved efficiency is an advantage in that the amount of generated light desired — the first step in the lighting design — may be obtained at a moderate wattage; moreover, various high lumen lighting applications, of the order of several foot-candles, may be inordinately high in cost if not prohibitive with filament lamps. Rising values in lumens per watt as lamp design progresses will extend the vantage of the mercury vapor lamp.

Life

Long life is a second basic feature. Lamps are capable of burning several times the burning interval of standard incandescent lamps. The published rated average life in hours of the four pre-

dominating lamps used in street lighting service are given in Table II.

Instances have been observed in which mercury lamps have been burned in service for excessively long periods, upwards of ten to twelve thousand hours or more. That a lamp can endure long burning is not necessarily fitting performance in delivering light, and the practice of stretching out lamp burning hours in service unduly is a negative factor unless the lamp efficiency holds up well or is possibly improved through lamp design.

Lumen Maintenance

Lumen maintenance is a material element of lamp design; consequently, satisfactory and efficient lighting depends upon adequate knowledge of the lumen output throughout the life of the lamp.

An example of the mercury vapor lumen maintenance characteristic is shown in Fig. 4, with the EH1 lamp compared with the 15,000-lumen series and multiple incandescent lamp. The light output decrease rate varies with the type of lamp, but it is observed that the mercury lamp follows the curve of the multiple filament and that the lumen output falls off by a greater percentage for the life of the lamp than the filament type.

The facts of lumen maintenance, particularly with long life lamps, is important in the engineer's calculations as to minimum footcandle levels. Good practice in applying lighting takes into account maintenance of the designed footcandle level. The application engineer has effected this as one method by using initial lumen values and then applying some sort of composite depreciation factor representative of lamp lumen depreciation and light loss due to dirt collection on the luminaire. A more positive solution is to base the lamp depreciation on some "average" as mean lumens or light output at 70 per cent of life and a realistic luminaire cleaning factor based on field conditions.

Published lamp data now are available for various lumen values other than initial, and the use of mean or average lumens is suggested as an adequate ruling basis in the lighting design, with the 70 per cent value useful probably in group replacement practice.

Lumen maintenance will be referred to further in a following section.

TABLE II.—Lamp Designation, Initial Lumens and Rated Average Life in Hours of the 400- and 250-Watt Mercury Lamps.

Lamp Designation	Initial Lumens Vertical Burning Position	Rated Average Life Hours
H400 — E1 or EH1	20,000	5000-6000
H400 — A1 or AH1	15,000	6000
H250 — {A5 or AH5 / C5 or CH5}	11,000	5000-6000
H400 — J1 or JH1	17,000-19,000	5000-6000

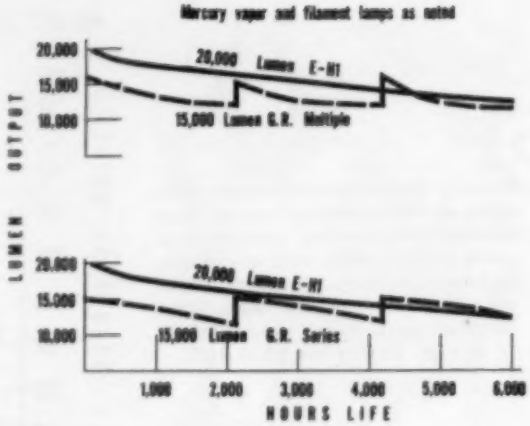


Figure 4. Comparison of average lumen maintenance. Lamp lumen values taken as follows: Mercury: mean lumens, 16,200, 6000-hour burning interval. Incandescent: G.E. Multiple — mean lumens, 13,000 on 3000-hour rated life, 2100-hour burning interval. G.E. Series — mean lumens, 13,250 on 3000-hour rated life, 2100-hour burning interval.

Lamp Ratings — Horizontal Burning Position

The horizontal positioning of mercury sources, crosswise of the travelled way, has become predominant in luminaire design. This provides excellent lateral distribution patterns through vertical angle control, emphasizing the optical suitability of mercury in comparison with incandescent.

Such lamp position introduces the contingency that lamp position other than vertical results in small variations in light output. This change is attributable to increased thermal losses in the arc tube walls.[3] Laboratory tests simulating field conditions confirm the fact that the loss in efficiency may reach several per cent of the lamp's vertical burning lumen output. An example of the variation is shown in Fig. 3, previously shown.

Published average lumen initial values for the three prevailing lamps are as shown in Table III.

In accepting horizontal lamp burning service as prime practice in street lighting, attention is being given to the securing of the lamp's rated lumen output and subsequently realize on the high luminaire efficiencies incorporated in luminaires today.

Compensating magnets, whether required for arc centering or not, partially reduce the efficiency loss.[3] But more interestingly, the rated lamp lumen output may be obtained by operation on a ballast

TABLE III.—Initial Lumens.

Lamp Type	Vertical	Horizontal
EH1	20,000	19,400 Without magnet
AH1	15,000	14,000 With magnet only
A and CH5	11,000	10,800 With or without magnet

designed to provide the rated watts to the lamp in a horizontal position. This may require 12 to 20 watts more of ballast input, allowing for certain small differences between makes of ballasts. Such type for the 400-watt lamp is now operating on the author's utility company's lines and lamp and ballast characteristics are being studied. The manufacturer's recommendation is that such ballasts should be used with horizontal lamp burning position only.

Supply Voltage

Good regulation of mercury lamp voltage is necessary to (a) maintain lumen output and (b) derive the designated lamp life.

Series circuits incorporate quite accurate current regulation to the ballast and lamp under the normal regulating characteristics of the constant current transformer.

With multiple supply, the lamp manufacturers' recommended limits in line voltage is five per cent plus or minus of the ballast tap setting. Below this norm, lamp starting is difficult, causing excessive electrode active material erosion or the voltage may be insufficient to flash the lamp; at high voltages, lamp life may be shortened by heating from the overwattage. Both operating cases may be serious hazards to the lamp, depending upon the degree of variation from the designed voltage range of the lamp.

The increase in multiple operation of street lighting lamps has pointed up the essential of proper ballast terminal voltage, accomplished through voltage regulation of the feeder circuit from which the lamp ballast is fed or by regulation incorporated in the ballast itself. The latter equipment is a recent development, taking the form of a static or a moving-coil regulator, to provide constant current (and, hence, constant wattage) to the secondary under varying input voltage over a rather wide range. Installations of the static type of regulator are in service on the System, and operation is now under careful analysis.

Operating Costs

It is generally understood in dealing with the economics of lighting systems that this type of service abounds with variables due to dissimilar field conditions, construction methods and variance in policy and practice.

However, the component — the lamp and its luminaire — lends itself to comparison between various lamp and luminaire combinations and significantly various light sources as well.

In Fig. 5, comparisons are made between mercury and incandescent units, showing the annual fixed charges and maintenance cost of equipment (including auxiliary, if any) and the capacity of the lamps in watts for each size as shown. The annual demand and energy cost at the luminaire will depend upon the power rate that applies to the problem at hand.

The sum of these two items for a given lamp is the annual cost for the "raw" light generated in one lamp and its luminaire. Utilization and maintenance factors follow in determining the final lighting design. But the interesting aspect of the comparison is the use of mercury vapor for upgrading lamp sizes of an incandescent system to furnish effective lumens more economically and to meet higher average footcandle problems with a minimum of lamp installations. Thus, by reason of

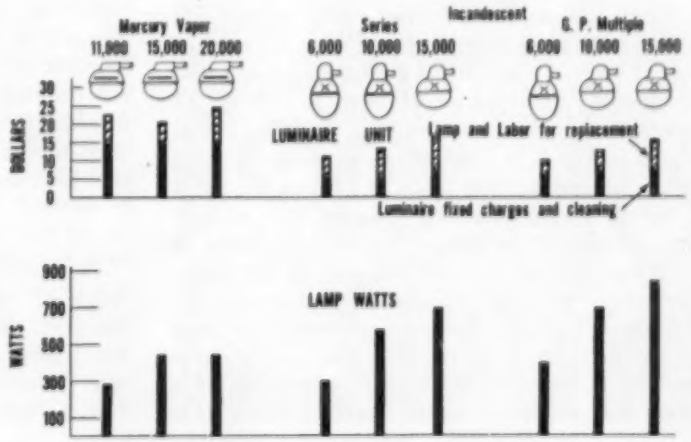


Figure 5. Comparison of annual cost of luminaire unit and lamp watts. Luminaires are standard commercial units, I.E.S. Types II, III and IV. Carrying charges taken at 15 per cent, lamps at 30 per cent from list price.

longer spacing, 20,000-lumen lamps are now fulfilling lighting that utilized 10 to 15,000-lumen incandescent lamps, and 15,000-lumen mercury in place of 10,000-lumen incandescent. The 11,000-lumen size, in instances, replaces the 6000-lumen incandescent at a small difference in operating cost.

As is appreciated, any comparison must be qualified. But as an example, where the investment for multiple primary service is the same, the possible savings between mercury and incandescent operation for comparable sizes is of the order of the difference in energy consumption; with series primary, the differential in savings is narrowed depending upon the manner of meeting the low power factor of series ballasts operation.

Looking toward the applicability of small wattage sizes of mercury lamps, trial installations have been made with the 100-watt, 3300-lumen lamp which, with its one-inch arc length, gives highly satisfactory performance in luminaires with optical systems designed for filament lamps, in both enclosing globe and open luminaires. While it is adaptable physically, the annual cost is high since the lamp price is proportionately higher and also is influenced by present low demand. It has long life, but lumen maintenance suffers somewhat. Nevertheless, an ultimate "small" wattage size in the 2500-6000 lumen incandescent range as applied on residential and light traffic streets is a present problem for the lamp designer in producing a lamp which, through efficiency and other properties, may compete with incandescent.

Useful Life of a Lamp

The question of lamp life and the most economical time to replace such a device is more complicated with mercury lamps than incandescent. Lamps may be burned until failure, or until a point where they become uneconomical in producing light or where they no longer meet the requirements of the lighting job.

Lamp life, as the published rated average life values in burning hours, is based upon the average life of large representative groups under specified conditions. Performance of large groups of A1 lamps may be demonstrated by a mortality curve, shown in Fig. 6, as illustrative and not as an exact curve. A certain percentage fail before the rated life, others burn considerably longer than average life. Obviously, the steeper the mortality curve as it passes through the 100 per cent of life point, the greater the degree in uniformity in meeting the average life rating. However, the value of a lamp is not determined by its life alone, and a curve serving to represent the lumen depreciation of a lamp is superimposed on the mortality curve. It is

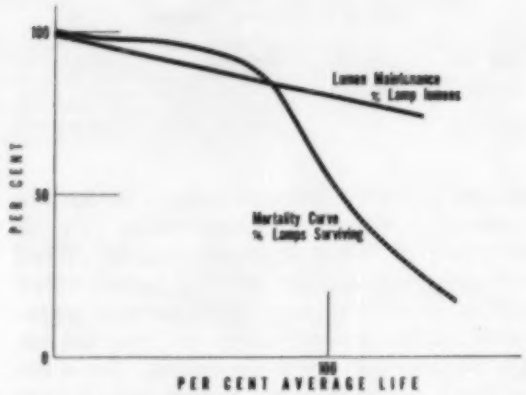


Figure 6. Lamp life characteristics typical of Hg lamps.

evident that the rate of depreciation of lamp efficiency is a highly important factor among the several involved in determining the economics of a lighting job.

Lamp renewal practice has followed random burnout replacement and considered necessary in past years to obtain good average lamp life. But as greater uniformity of burning hours was attained, operating experience indicated savings and operating conveniences through group replacement. A few installations of 400-watt lamps are now under group replacement with around 70-80 per cent of the lamps surviving at 100 per cent of rated average life in some cases, and the 250-watt lamps show around 90 per cent surviving at rated average life. The labor cost per lamp is one-half to one-third less than for random replacement.

Continuing investigation is necessary on lamp life under service conditions to realize the optimum economic advantages of such practice and the factors having the most weight are: adequate data on lamp depreciation; time and labor for lamp replacement; and luminaire maintenance data.

As to the latter point, a sampling of luminaires under varying atmospheric conditions shows up to 15 per cent light depreciation due to dirt for luminaires in service upwards of one to two years without cleaning. Local conditions will govern schedules, but obviously luminaire cleaning is extremely important with long burning lamps in maintaining the desired lighting levels.

Fluorescent Lamps

The fluorescent lamp is a new and unique application of light source in street lighting in this country. Functionally, the lamp performs much like mercury vapor sources but with certain definite variations, principally the effect of temperature on light output. Parallel to this is its inherent

low brightness through large surface area which directly affects application techniques.

It has been shown that the light output of a fluorescent lamp is dependent upon the bulb wall temperature. That in turn is dependent upon two factors, the type of lamp or more specifically its current loading and the surrounding ambient temperature of the enclosing luminaire. Therefore, street lighting design with fluorescent lamps involves the effect of external ambient temperatures of light output of the luminaire.[6]

As to further operating points, the fluorescent is a high efficiency, long life lamp with good lumen maintenance characteristics. Full light output is developed within a few seconds. The useful life problem with fluorescent lamps follows the mercury lamp case. The latest commercially used lamp in street lighting has even longer average rated life, 7500 hours (at 10 hours per start) and a more moderate lamp depreciation rate than mercury. More field experience is desired and the extending trend in average life emphasizes the importance of luminaire cleaning schedules.

Reference is made only to the most recent lamp in street lighting use, the 100-watt 72-inch T12 standard cool white, rapid-start lamp, rated 7500 hours average life, 5350-lumen (at 80°F), which operates at a high current to provide better performance over the normal outdoor temperature range (probably −20° to +80°F).

Experience with an installation of four-lamp 21,400-lumen (initial) luminaires, points up certain advantages, namely, low brightness even at restricted mounting heights by reason of the large surface area of the lamp and luminaire, the infrequency of lamp replacement operations in busy areas, and the quality of illumination.

Observations of this and other installations, bear out the property of bright pavement patterns on the road surface to facilitate silhouette seeing and particularly the effectiveness of reflected brightness under wet pavement conditions. The distinctive quality of linear-source, low-brightness fluorescent lighting has apparently introduced new criteria in evaluating illumination of street surfaces; opinion has been expressed that fluorescent lighting provides a greater degree of visibility than under equal footcandles of modern filament or mercury lighting.[7] This may or may not be another way of expressing the veiling effect of glare with higher brightness sources. But the circumstance of relative visibility posed by fluorescent with other sources emphasizes the problem of developing a technique that removes the subjective element in evaluating lighting as much as possible.

The progress of these lamps is of major interest throughout the industry. Since both fluorescent and mercury lamps are highly efficient with long life, future acceptance may point up the importance of low brightness (inherent in fluorescent) versus better control (inherent with mercury). Such items as temperature sensitivity, limited color range, and others, will probably be minimized by technical developments.

Sodium Vapor Lamps

Historically, sodium vapor pioneered the discharge lamp in street lighting service. Probably the feature most noted from the time of its introduction has been the familiar yellow cast of the light; however, this new type of light drew attention to high efficiency light generation and low brightness quality of the source and its luminaire. Improved visibility was demonstrated by the reduction in objectionable glare and the broad and more uniform light distribution pattern on the roadway.

The maximum practical size source in commercial use is the NA-9, 180-watt, 10,000-lumen lamp. It is now considered that mercury sources, both concentrated and elongated types, afford lumen output and maintenance and particularly operating advantages that surpass the sodium for most lighting applications.

Spectral Qualities and Color of Vapor Sources

Color has definitely become a part of lighting in the public's mind, and appearance and effects of light sources for public way illumination must be taken into account. Mercury vapor lamps used for lighting primarily produce as much energy as possible in four important lines in the visible spectrum (red excepted). This accounts for the blue-green-white color of the so-called straight mercury. The bright, brilliant appearance has insured acceptance over objections to the color discrimination properties for street and highway illumination.

The use of the strong line in the ultraviolet region of the quartz mercury arc[2,4] to fluoresce phosphor coated lamp flask surfaces has produced the mercury fluorescent lamp as sometimes termed. The improved color extends the versatility of mercury vapor where straight mercury would be objectionable or where added impressiveness is desired. Some lamp efficiency is sacrificed as well as lower utilization effected by the slightly greater difficulty of controlling the light emitted from the source. A design to provide closer linear spacing of luminaires is required for adequate pavement brightness by reason of light loss at the higher angles and other factors as mentioned.

Sodium, almost monochromatic due to the narrow spectrum in the yellow region, causes objects to appear as yellow or as shades of yellow. Though color has limited its acceptance, it nevertheless serves as cautionary illumination in particular highway locations.

Fluorescent lighting is of pleasing quality and described as a crisp white light that provides favorable rendition of colors and an improved over-all lighted appearance of the street.

Conclusion

In presenting some of the more important aspects of vapor lamps and their application, it is hoped that (1) these will prove of definite interest to the application engineer and (2) draw attention to the need for constructive appraisal of operating practice and procedure.

Experience at this stage with vapor lamp lighting indicates its suitability as to technical properties for any type of public way lighting and under a wide range of temperature and climatic conditions. High lamp efficiency affords marked economic advantages, and the lamps are adaptable to luminaires with optical systems that furnish improved visibility and comfortable seeing through low brightness and uniform distribution properties. Of importance is the color and attractiveness of mercury and fluorescent lighting and the ability to give the effect of a well lighted street.

The industry needs more comprehensive field service data on lamp operation, greater uniformity of product and improved lumen maintenance. Such progress can be attained through effort and interest of the equipment manufacturer and user of the product.

Acknowledgments

The author wishes to acknowledge the contributions of operating data made by C. E. Whitaker and R. J. Karazia of the New England Electric System and to express his appreciation for the assistance rendered by representatives of the lamp industry.

References

1. *The American City.*
2. Beggs, E. W.: "New Developments in Mercury Lamps and Their Application." ILLUMINATING ENGINEERING, Vol. XLII, No. 4, pp. 435-465 (1947).
3. Noel, Edward B.: "Mercury Lamps Redesigned for Improved Light Output and Performance," ILLUMINATING ENGINEERING, Vol. XLIII, No. 9, pp. 1044-1060 (1948).
4. Fraser, H. D., and Till, W. S.: "Color Correction and Other Important Improvements in Mercury Lamps," ILLUMINATING ENGINEERING, Vol. XLVII, No. 4, pp. 207-213 (1952).
5. Burns, C. H., Freeman, G. A., and Rowten, D. W.: "Electrical Design Data for Mercury Vapor Lamp Circuits," ILLUMINATING ENGINEERING, Vol XLVII, No. 3, pp. 149-155, (1952).
6. Bock, J. E., and Franklin, J. S.: "Effect of Temperature on Fluorescent Street Lighting Luminaires," ILLUMINATING ENGINEERING, Vol. XLIX, No. 2, pp. 63-118 (1954).
7. Houser, Philip H.: "Some Observations of Fluorescent Street Lighting Here and Abroad," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 10, pp. 505-555 (1953).

DISCUSSION

A. G. PENNY:* The point has been made by Mr. Young that at low wattages the economics of mercury lamps become progressively less attractive. That is also our experience in England where we find that for units of less than about 10,000 lumens the sodium lamp is the cheapest proposition.

A good deal of obsolete gas lighting in side streets, minor traffic roads and residential areas is now being removed because of the high cost of maintenance and, despite objections in residential areas to the unpleasant color, sodium is being installed. For the small streets 45-watt lamps are generally used, and 140-watt for the traffic routes. It should be remembered that British roads are generally much narrower than those in the United States.

R. M. SWEITLAND:** The street lighting fraternity — user and manufacturer alike — will benefit from the (a) actual data presented, (b) questions raised and needs and trends outlined in this excellent paper. Mr. Young merits our vote of sincere appreciation.

Among the numerous points which he has discussed, we briefly refer to:

(1) The logical expansion of currently-used 400-watt and 250-watt mercury lamps to include both *larger* and *smaller* sizes. There appears to be an unmistakable need for such lamp size amplification.

(2) There is considerable interest shown in obtaining more operating field experience on group replacing mercury lamps. Relative economy appears to render the 250-watt H-5 and 400-watt A-1 sizes most logical candidates, at present, for such practice.

(3) The advised use of "mean" lumen output (of mercury lamps) — plus a luminaire dirt depreciation factor — when calculating "maintained" footcandle levels is pertinent and is being favorably regarded. This practice is advocated in the latest revision of the "American Standard Practice for Street and Highway Lighting."

(4) Relative to fluorescent lamps in street lighting practice, we heartily concur in the need for "new criteria in evaluating illumination of street surfaces." Accumulating experience, both here and abroad, in fluorescent street lighting is convincing many street lighting engineers of the seeming improvement in resulting visibility at equivalent average footcandle levels. Visibility appraisal by personal judgment and experience — still valid and permissible in this country — surely needs substantiation by more conclusive and accepted instrumentation.

Concerning vapor lamp operation, in street lighting practice, under low ambient temperature conditions, another encouraging report has just been received from Edmonton, Alberta, to the effect that: (a) 400-watt E-1 mercury lamps are starting satisfactorily at −40 F and operating under −53 F temperatures; (b) rapid-start T-12 100-watt fluorescent lamps (in a 4-lamp luminaire) are starting satisfactorily at −24 F and operating under −32 F temperatures. (Part-winter experience, only, is available on this installation.) Low voltage multiple circuits prevail in both instances.

Thus, properly-designed lamps, luminaires and ballasts appear to have successfully solved these low-temperature operating problems.

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R. G. SLAUER:* In his opening remarks, Mr. Young mentions that fluorescent lamps merit intensive study and adequate trial. It seems certain that this will occur over the next few years since the number of units available for such study has greatly increased during the past six months.

For utility and governmental operating men, one problem of convenience and maintenance immediately presents itself. This concerns standardization. The manufacturer with the broadest commercial experience in the fluorescent roadway lighting field has employed the rapid-start type of fluorescent lamp in his fixture. Yet of the three lengths of rapid-start lamps available from major lamp manufacturers, all three have different base types. This forecasts inventory and maintenance problems as "family" fixture designs are introduced. Furthermore it is fair to ask why one of these three bases wouldn't automatically be superior to the other two, evaluated of course on the basis of street lighting requirements. I think we should guard against the same type of errors committed in just lifting the mercury lamp from interior to exterior use.

W. S. TILL:** Mr. Young is to be congratulated for having made a valuable contribution to the literature and for his interest in promoting better street lighting.

In connection with the lighting of residential or light traffic streets, the author mentioned the 100-watt 3300-lumen mercury lamp and cited the need for other mercury lamps in the 2500- to 6000-lumen range. I am glad to report that one such lamp has been perfected very recently and is now available in limited quantities. Designated A-H22, the new mercury lamp is rated 175-watts, 6800-lumens, initially (mean lumens in the neighborhood of 6000) and 4000-hours average life. Development of the new 175-watt lamp was stimulated greatly by Mr. Young's interest. In addition, the old 100-watt lamp has been redesigned and rerated at four times the previous 1000-hour life. Both the 100-watt and the 175-watt are now available with color correction, if desired.

I should like to comment briefly on the operation of the 400-watt E-H1 lamp in horizontal burning position. Even at full rated wattage, it will lose approximately 3 per cent of its light output burning horizontally as compared with vertically. Increasing the wattage by 3 per cent will restore full lumen output. We find that this slight over-wattage has no measurable effect on lamp life or lumen maintenance. This is readily understandable when one considers that actual service variations in lamp wattage often amount to a great deal more than 3 per cent. This is caused by variations in the individual lamp, ballast, or line voltage supply. Recognizing these factors, the lamp manufacturers have set 10 per cent over-wattage or under-wattage as the desirable limit for continuous lamp operation and are making the lamps with close manufacturing tolerances to make this practical.

Regarding visibility under fluorescent lamps for street lighting, there are some people who think that mercury lamps afford better visibility for equal footcandles, based on the Perkinje effect. This matter needs further study, as Mr. Young has recommended.

The subject of group replacement of mercury lamps is of current interest, and we know of a number of cities that are already trying it. Since the lamps last so long, if group replacement is not practiced, dim lamps must somehow be removed from service in order to keep up the footcandle level. Various means may be used to cull out the old dim lamps, such as visual observation, photometric tests, and the keeping of individual pole records. Each method has its limitations. We hope that any who have successful systems in use will add to the data being collected by Mr. Young and the lamp companies.

D. A. TOENJES:* Based on his own operating experience, Mr. Young's paper offers a comprehensive summary of present mercury vapor and fluorescent lamps for street lighting. We believe that this will prove to be a valuable reference throughout the industry.

Mr. Young might wish to include a 25,000-lumen filament lamp in Fig. 2. While such a lamp is available, its use is quite limited.

In the section entitled "Lamp Ratings—Horizontal Burning Position" there appears the statement that "rated lamp lumen output may be obtained by operation on a ballast designed to provide the rated watts to the lamp in a horizontal position." It is true that a slight increase in wattage to the ballast can bring the lamp wattage back up to the rated value. However, when a vertical-burning lamp is turned to a horizontal position, its efficiency is reduced. Therefore, bringing the lamp wattage back up to its rated value (400 watts, for example) does *not* mean that its light output at 400 watts in the *horizontal* position will be as high as at 400 watts in the *vertical* position. The efficiency of a horizontal-burning lamp can be somewhat improved by the use of an arc-correcting magnet. Also, over-wattage operation of a lamp in a horizontal position can bring it up to a light output equivalent to that for vertical operation at 400 watts.

However, we can not endorse every lamp-and-ballast combination that would so raise the light output by over-wattage operation. Although most of the lamps so operated would perform satisfactorily, it is likely that a few of the lamps near the top of the lamp-voltage tolerance range would be seriously over-wattaged, leading to short life from overheating or the effect of abnormally high lamp current. There is also the likelihood of poor lumen maintenance if the ballast design results in poor wave shape of lamp current, usually accompanied by high rms and peak values. The factors affecting lamp performance include this rms value of lamp current, and its wave shape, as well as wattage delivered to the lamp and the starting characteristics of the lamp-and-ballast combination.

In the section entitled "Useful Life of a Lamp," Mr. Young has mentioned possible savings through group replacement of mercury lamps. A number of utilities are now using group replacement on a trial basis. The feasibility of such group replacement depends largely upon the shape of the lamp mortality curve — the steeper the curve, the better. The shape of this curve has been improving steadily with improvements in lamp design. Such continuing improvements are making group replacement of mercury lamps more and more feasible.

W. H. EDMAN:** The street lighting application and operating engineers will undoubtedly appreciate the value of this paper. I consider this a milestone in our progress with mercury vapor sources, and the street lighting industry should be grateful to Mr. Young and his company for compiling and releasing this much needed information.

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**Westinghouse Electric Corp., Bloomfield, N. J.

*General Electric Co., Nela Park, Cleveland, Ohio.
**The Holophane Co., Newark, Ohio.

Characteristics of mercury vapor sources — It is time-consuming and difficult to obtain complete performance data in the laboratory as related to actual operating conditions. This report shows the necessity for a complete reappraisal of the different types of street lighting systems in use today. Those who have realistically evaluated the important cost components of street lighting know that a reduced system cost will result when fewer locations with larger lumen sources are used. This has become more pronounced with the use of long life mercury vapor sources which reduce the frequency of lamp changes. This maintenance component, due to the ever rising labor costs, has increased at a much faster rate than the equipment cost component. The data presented in Mr. Young's paper surely confirm this trend.

As to the comparison made in Fig. 5, I would like to suggest this include more than lamp size and type of luminaire. I should like to see street utilization efficiency of the luminaire brought into the comparison. For a long time I have believed it preferable to consider system mileage as the ultimate basis for street lighting costs, rather than an individual type of pole, luminaire and lumen size of lamp. If a given class of street is lighted to certain levels and quality prescribed by "The American Standard Practice for Street and Highway Lighting," then the most economical type and size of lamp, spacing, etc., will take care of itself. Would the author care to comment on this thought as a practical possibility for the future?

JOHN W. YOUNG:* The comments of Messrs. Penny, Swetland, Slauer, Till, Toenjes and Edman are much appreciated. They emphasize several aspects of vapor lamp operation and performance in which solutions must come through more comprehensive field experience and from continued laboratory research. Lamp performance in the horizontal burning position is a case in point. Reduced life from too strong over-wattage operation and poor lumen maintenance due to poor wave shape of lamp current are recognized as possible limitations and must be resolved before the "standard" lamp is adopted. Experience is being gained with this practice, as noted by the comment on horizontal burning of one type of lamp, the E-H1. The indication is that with a 10 per cent over- or under-wattage limit in operation, a 3 per cent increase to restore full lumen output is not of major concern.

*Author.

Compensating for lamp efficiency loss by increasing the wattage seems a feasible method and further laboratory tests by the lamp designer particularly and ample field service data are highly desirable. Though our operating experience is limited, lamp operation as to burning hours in service on this type of circuitry is apparently following that with conventional ballast operation. Any conclusion as to lumen maintenance will depend upon lumen output testing of lamps in service selected at various stages of burning hours.

Other points of operation cited are of interest in the progress of mercury lamp application in street lighting. Group replacement of lamps is being extended which reflects steady improvement and refinement in lamp design and greater uniformity of fabrication. Satisfactory starting in low ambient temperature conditions is confirmed. On the subject of economics of mercury lamps, the comment that lamps below about 10,000 lumens become less attractive is, in general, our experience to date; however, the possibility of lamp ratings below 250-watt 11,000 lumens, competitive with other sources, has not been exhausted.

The comment on standardization with regard to the newest light source — fluorescent lamps — is timely. Consideration of the operating man and maintenance will aid in advancing the adoption of a new development, as fluorescent luminaires.

The viewpoint of "system mileage" as the final basis for costs which involves selecting the lamp and luminaire that do the best job overall is endorsed by the author. Fig. 5 pertains only to the generated light of a lamp. The next step — most important in the calculations — is consideration of the utilization efficiency and conceivably several luminaire and lamp combinations might be available to the application engineer and the particular street and traffic conditions involved. Street physical factors vary considerably and compromises must be made at times. But, the consideration of large unit lengths of street should lead to more adequate lighting solutions. Solutions on a strictly lamp for lamp basis have their limitations.

It is hoped that the various topics brought out in the paper and the discussion have directed thoughtful attention to the vapor lamp and its performance in the street lighting art at this stage of its development.

February 1 — Deadline for 1955 Conference Paper Outlines

A deadline of February 1 has been set by the Papers Committee for the submission of outlines of proposed papers for the 1955 National Technical Conference.

Outlines, in triplicate, of proposed papers should be mailed to:

Dr. R. M. Zabel
Chairman, I.E.S. Papers Committee
Westinghouse Electric Corp.
Bloomfield, New Jersey

INSTALLATION AT MAPLE END CROSSING, BRISTOL, CONNECTICUT.

Lighting a Dangerous Intersection

LIGHTING OBJECTIVE: To illuminate a dangerous irregular intersection of several streets and a railroad, utilizing existing wooden poles and minimizing distracting luminaire brightness.

GENERAL INFORMATION: Fig. 2 shows the layout of this intersection of five streets (Farmington Avenue and North Street are U. S. Route 6) and the railroad. At the peak rush hour 1200 vehicles pass through the intersection. Train traffic is about one per hour.

INSTALLATION: Fig. 2 shows the location of the ten General Electric Company Form 206 fluorescent street lighting luminaires (No. A 3006, each containing four 72-inch 100-watt rapid start lamps) and the resultant illumination levels measured at an ambient temperature of 42F. All units are mounted 30 feet above the pavement on wooden poles.

This fluorescent luminaire provides a broad I.E.S. Type I distribution (see Fig. 4) with low source brightness. Type I was considered advantageous because it would give maximum pavement brightness in the normal traffic lanes. A broad Type I was necessary to reach the central area of the intersection. In the six months preceding this installation three reportable accidents ($50.00 damage minimum) occurred involving six automobiles. For the same six-month period after relighting no accidents were reported.

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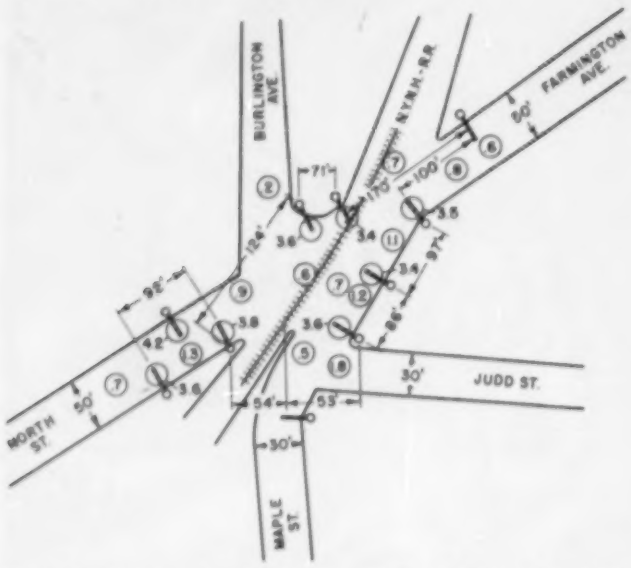

Figure 2. Plan view showing location of street lighting standards and resulting illumination levels. (Circled figures indicate foot-candles.)

Figure 3. Detail of luminaire.

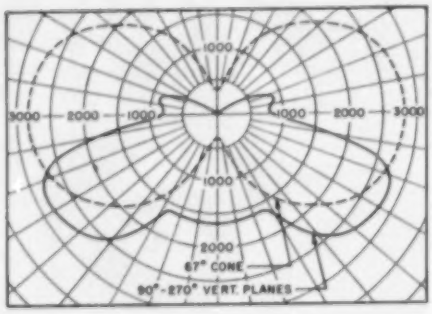

Figure 4. Luminaire candlepower distribution curve.

Lighting designed by Clyde La Rocque, Industrial Sales Engineer, and R. E. Ballard, Street Lighting Engineer, Connecticut Light and Power Company, Berlin, Conn.

Lighting data submitted by R. E. Ballard and Clyde La Rocque, Connecticut Light and Power Company, Berlin, Conn. as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Effect of a Peripheral Glare Source Upon the Apparent Brightness of an Object

By GLENN A. FRY
MATHEW ALPERN

Why does an object viewed near a glare source appear less bright than it does if there is no nearby glare source? This question was studied as Project #17 of the I.E.S. Research Fund, and their findings reported herein, including a method of evaluating loss of visibility.

THE PROBLEM — A given object or task, when viewed with a glaring light source nearby, appears less bright than when the glare source is removed. Let us use an example to explain how this can happen.

In Fig. 1, the bridge lamp introduces a glare source in the field of view. This glaring light is projected into the eye and causes stray or scattered light to fall over that area of the eye (the fovea) where the image of the music notes is recorded, thus producing a veiling glare or washing out effect and making the object look dimmer. This same veiling effect can be produced by a patch of brightness interposed between the object and the eye whose image overlays the image of the object being seen in the eye. If the effect of a glare source is the same as an overlaying veiling brightness, then one is led to believe in the principle that the combined effect of a number of glare sources in different parts of the visual field can be predicted by adding the *equivalent* veiling brightnesses falling on the fovea from the individual sources. This also lays the foundation for calculating the effect of any bright areas (even though not recognized as glare sources)in the field of view.

Figs. 1, 2 and 3 are examples of illumination accompanied by glare. Even though the glare source adds light to the retinal image of the object being seen, it decreases the apparent brightness of the object.

The Tests

Continuously Exposed Glare Sources — It has been shown previously[1] that a glare source in the visual field seems to reduce the brightness of an object viewed with one eye as compared to a similar object seen by the other eye. Since it has been concluded[2] that there is no communication from one area to another within the eye, this effect must be the result of stray light or scattering of light in the eye media which lays a veil of light over the image of the object of interest.

In the first experiment a test object to be viewed by one eye was superimposed by a patch of veiling brightness and the object's actual brightness varied by an observer until it appeared to him to match a similar object with no veiling brightness, viewed by the other eye. The relative difference between the actual brightnesses of the two test objects was recorded as a *glare index*. This glare index was found to be a logarithmic function of the veiling brightness, as shown in Fig. 7.

In the second experiment the veiling brightness was replaced by two glare sources symmetrically

Figure 1. A common example of peripheral glare — a piano with a too bright lamp.

This report is sponsored by the I.E.S. Research Fund as Project No. 17. Approved by the Research Executive Committee and by the Board of Trustees.

AUTHORS: School of Optometry, the Ohio State University, Columbus, Ohio. The I.E.S. Research Fund provided a graduate fellowship for the junior author and technical assistance. The senior author is indebted to the Bausch & Lomb Optical Company for a grant for research in physiological optics which has made possible his participation in the investigation.

Figures 2 and 3. More common examples of peripheral glare — workman in front of window with direct sunlight in his eyes, and glare from opposing headlights on a highway.

spaced on each side of the test object. The same results were obtained, indicating that glare sources offset from the axis of vision have the same effect as an area of veiling brightness overlaying the seeing task. The experimental data show that

$$\beta_e = \frac{22.4\,E}{\theta^{2.5}}$$

where β_e is the equivalent veiling brightness
E is the illumination produced at the eye from the glare sources
θ is the angular distance (subtended at the eye between the glare source and the test object).

This relationship is very nearly the same as ones determined previously by Holladay,[4] Stiles,[5] and Stiles and Dunbar.[6]

Momentary Exposure of Glare Sources—Earlier work[1] demonstrated that exposure to a glare source for various lengths of time before the test object was viewed had a constant effect, regardless of the duration of the pre-exposure after the first 200 milliseconds. The same study investigated also a momentary exposure of the glare source before the test object with a time interval between the glare source and exposure of the test object. The equivalent veiling brightness increased as the interval increased up to 50 milliseconds, and then decreased and disappeared completely when the interval between the two stimuli was as long as 150 milliseconds.

The present project involved a similar experiment using an area of veiling brightness, rather than the glare sources, exposed an interval of time before or after a 5-millisecond exposure of the test and comparison objects. The maximum glare effect was found to occur when the glare source preceded the test object by 50 milliseconds. The veiling glare affects the apparent brightness of the test object even when it follows the test object by as much as 100 milliseconds (Fig. 13).

The rate of recovery from adaptation to a peripheral glare source depends[1] on the length of exposure to the glare source despite the fact that the inhibitory (glare) effect reaches a constant level 200 milliseconds after the beginning of the exposure and retains this level during the rest of the exposure. Appendix C shows that this effect is the same as that obtained by direct adaptation to the equivalent veiling brightness.

Conclusions

Basic — The apparent decrease in brightness of a directly viewed test object produced by a nearby glare source (sometimes called "disability glare") can be accounted for in terms of the veiling glare produced by stray light falling on the fovea of the eye. The same effect can be produced by an overlaying patch of veiling brightness.

The changes in brightness that occur immediately following the onset of a peripheral glare source as well as the changes which occur following removal of the glare source can all be accounted for in terms of the veiling glare produced by stray light falling on the fovea.

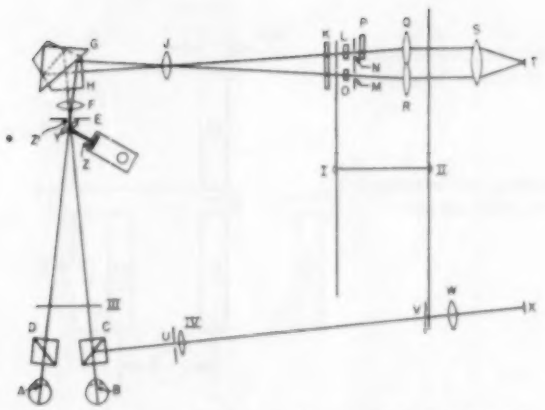

Figure 4. Apparatus for investigating Schouten-Ornstein effect.

A — center of entrance pupil of left eye

B — center of entrance pupil of right eye

C — beam splitting prism permitting right eye to see opening(s) in diaphragm *U* which are illuminated by light from aperture *V*

D — beam splitting prism making optical distance from *A* to *E* equal to that between *B* and *E*

E — diaphragm containing two rectangular openings, *a* and *b* as shown in Fig. 6

F, J — lenses forming a 2.2 mm diameter image of aperture *M* at *A*, and similar image of aperture *N* at *B*

G — right-angle prism; hypotenuse reflects light beam from aperture *M* to left eye

H — penta-prism; by means of two internal reflections directs beam from *N* to right eye

Arranged in two tiers with *G* above *H*

J — see *F*

K — Wratten neutral density filter

L, P — pair of cross polarized filters

M — see *F* and *R*

N — see *F* and *Q*

O — Wratten neutral density filter

P — see *L*

Q — lens which focuses image of filament *T* at *N*

R — lens which focuses image of filament at *M*

The optical centers of *Q* and *R* are separated by an amount equal to the separation of the two apertures *N* and *M*

S — collimating lens

T, X — ribbon filaments

U — diaphragm which can be adjusted to provide two rectangular openings *c* and *c'* as shown in Fig. 6, or a single circular opening *e* as in Fig. 5

V — aperture adjustable in vertical and horizontal direction so its image can be made to fall at exactly the same point as the image of *N*

W — lens forming an image of ribbon filament *X* at aperture in diaphragm *V*

X — see *T*

Y — horizontal mirror permitting each of the two eyes to observe the mirror image *Z'* of the bright spot *Z*. This mirror image *Z'* falls in the same plane as *a* and *b* and midway between them, as shown in Fig. 6

Z — see *Y* and *Z'*

Z' — fixation point, image of bright spot *Z*

I — rotating disk which exposes aperture *e* (see Fig. 5) for 5 milliseconds once each revolution, and has an opening to prevent it from interfering with the exposure of *a* and *b*

II — rotating disk on same shaft as *I*

III — diaphragm which screens the field of view so that each of the two eyes can see the fixation point *Z'*, but the right eye sees only the rectangular opening *b*, constituting the test object, and the left eye sees only *a*, constituting the comparison object.

IV — lens which focuses 2.3 mm diameter image of aperture *V* at *B*.

Practical — The implications of this study for practical problems of illuminating engineering are as follows:

The effect of a glare source on any aspect of foveal vision is dependent upon stray light. This lends support to the principle that the combined effect of a number of glare sources in different parts of the field can be predicted by adding the increments of stray light falling on the fovea from the individual sources. This lays the foundation for calculating the effect of any brightness areas or brightness distribution in the field of view. A procedure for doing this has already been outlined by Moon and Spencer.[10, 11]

Visualizing these conclusions in terms of everyday practice one can see where the results can be used to evaluate the loss of visibility of objects or people on the street or highway due to the glare of opposing headlights. (The more the overlaying veiling brightness is built up the less one can see the object of regard.) The same idea would also apply to low mounted floodlights on an athletic field, to theatrical spots and floods on theatrical stage or TV studio, to certain types of industrial lighting, and possibly to some extent to interior office and school lighting, if the luminaire or daylighting fenestration directs a large proportion of light toward the eyes. In fact, the concept would apply to large non-uniformities of brightness anywhere particularly if one is looking at darker detail surrounded by or adjacent to markedly lighter areas. Since the tests disclose a continuance

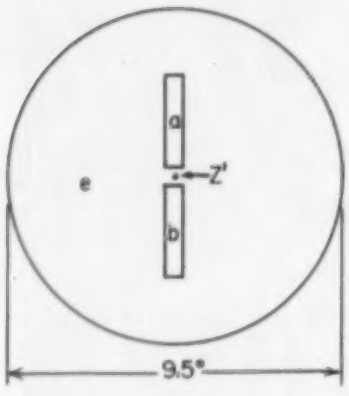

Figure 5 (left). Pattern for investigating the effect of a patch of veiling brightness.

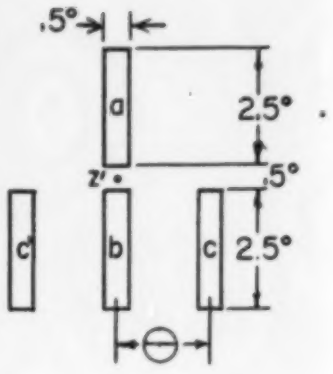

Figure 6 (right). Pattern for investigating the effect of glare sources.

of the veiling glare effect for a time after the removal of the stimulating source, the idea can be applied to eye movements in a room as one looks away from the brightness of the task to darker detail or looks back from a high brightness area in the room to the lower brightness task again.

Appendix A.—Apparatus and Its Operation

Fig. 4 shows the apparatus used for the experiments described in the subsequent parts of this report. The details of the apparatus have been described in a previous paper.[12] The subject sinks his teeth into a previously prepared biting board, bringing his head into an approximate position. He is then directed to fixate the fixation point Z'. The biting board which controls the position of the head is then adjusted until (1) the center of the entrance pupil B of his right eye coincides with the images of N and V, (2) the center of the entrance pupil of the left eye lies in the same horizontal plane as that of the right eye and (3) the cornea of the left eye lies at an equal distance from Z' as the cornea of the right eye. To aid this operation, a diaphragm containing a small circular hole for the right eye and a horizontal slit for the left is mounted between diaphragm *III* and the beam-splitting prisms, C and D. The assembly supporting the right angle prism G and the penta prism H is then rotated until the image of M falls at the center of the entrance pupil A of the left eye. The rotation of H does not affect the position of the image of N.

Lens W forms an image of ribbon filament X at the aperture in V. The rays from ribbon filament T are collimated by S, and Q focuses an image of T at aperture N; R focuses an image of T at the aperture M. The optical centers of Q and R are separated by an amount equal to the separation of the two apertures N and M.*

Experiments involving simultaneous momentary exposure of a and b preceded or followed by a momentary exposure of c (see Fig. 5) were made possible by means of electromagnetic shutters and rotating disks. The rotating disk *II* exposes c for 5 milliseconds once each revolution. By adjusting disk *I* with respect to *II*, a and b can be made to precede or follow c by any interval up to 300 milliseconds. A cam on a shaft rotating one-fourth as fast as the shaft carrying the two disks controls the two electromagnetic shutters which permit exposure of the targets once every four revolutions of disks *I* and *II*. A system of relays was also worked out to permit the operator to give a single exposure by pressing a key.

The brightness of the targets seen by reflection at C was varied by Wratten neutral density filters and by a pair of crossed polaroids placed at V. The brightness of b seen by transmission through beam-splitter C can be varied independently from that of a seen through beam-splitter D by a pair of cross polaroid filters L and P. The brightness of the target as seen through D can be varied independently of that of b seen through C by Wratten neutral density filters O. The brightness of targets a and b can be varied together by means of Wratten neutral density filters K. The entire apparatus is supplied with suitable baffles so that no extraneous light can enter the eyes.

Appendix B.—Detailed Procedure

B-1 — *Effect of a Patch of Veiling Brightness Upon the Apparent Brightness of the Test Object* — The stimulus pattern for this experiment is shown in Fig. 5. A patch of veiling brightness c having a diameter of 9.5 degrees is superimposed upon the test object b with its center falling at the fixation point Z'. The fixation point, test object b, and the patch of veiling brightness superimposed upon it are seen by the right eye. The left eye sees only the fixation point and the comparison stimulus a. The brightness β_a of a is kept fixed; the brightness β_b of b is varied in order to make it match a in brightness. For various levels of brightness for the veiling glare β_c one of the subjects (TH) made five settings of β_b. The results are presented in

TABLE I.—Data for T. H. obtained with the stimulus pattern in Fig. 5 showing the effect of varying β_c. β_c and β_b are expressed in footlamberts.

β_a	β_b	T	β_c	β_b	T
0	4.98*	0	55.8	17.06	2.42
1.116	5.30	.064	111.6	22.26	3.47
2.49	5.32	.048	223.0	23.12	3.42
4.70	5.86	.18	335.0	25.0	4.03
11.16	7.26	.46	558.0	39.4	6.93
22.32	9.62	0.94	1245.0	61.0	11.25
27.9	10.62	1.13	3350.0	110.5	21.2

*Value for β_a used in computing values for T.

*In some of the early experiments both N and M were illuminated by a piece of opal glass which in turn was illuminated from the rear by a single lamp. Also, in some of the early experiments a 100-watt inside-frosted lamp was used at X instead of the ribbon filament lamp.

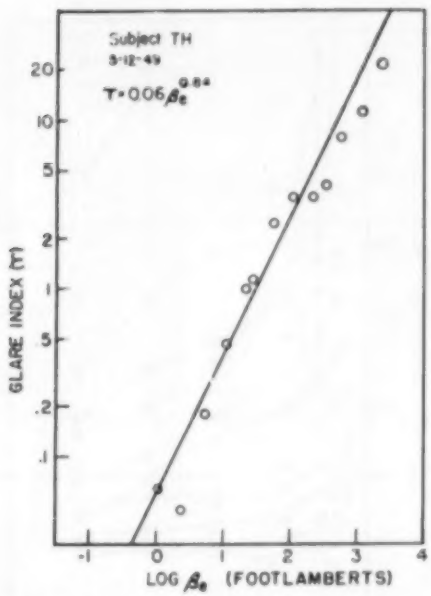

Figure 7. Results for subject T. H. obtained with the stimulus pattern in Fig. 6, showing the effect of varying the brightness of the patch of veiling glare, *e*.

Table I and Fig. 7. In Fig. 7 the data are expressed in terms of T and β_e. The symbol T represents a quantity which is called the glare index by Schouten and Ornstein[1] and is defined as follows:

$$T = \frac{\beta_b}{\beta_a} - 1 \qquad (1)$$

The important point is that β_b continually increases as β_e increases. If one begins with a match between β_a and β_b and then increases the veiling glare, this cuts down the perceived brightness of *b* in spite of the fact that it adds to the original brightness of *b*, and the brightness of *b* must be further supplemented to reestablish the match with *a*.

With much simpler equipment, this type of experiment was carried out with three other subjects who obtained the same type of result. The slope of the best fitting straight line varies from day to day between about 0.7 and 1.0. The value used for β_a in calculating T is based on a binocular match between *b* and *a* when the veiling glare is off, and any error in the determination of this value produces a marked effect on the slope of the best fitting straight line. Values of T are practically meaningless for small values of β_e where the difference between β_a and β_b is no longer significant. Variations in the relative sensitivities of the two foveas will also affect the results.

An explanation of how a patch of veiling brightness can reduce the apparent brightness of an object has been attempted in a previous paper.[3]

B-2—*Effects Obtained with Glare Sources* — The stimulus pattern for this part of the investigation is illustrated in Fig. 6. In this pattern the two rectangles *c* and *c'* constitute the glare sources and these are symmetrically placed on opposite sides of test object *b*. The distance from the center of *b* to the center of either of the glare sources is θ. For several different fixed values of θ the subject made five separate settings for the actual brightness of *b* which made the apparent brightness of *b* equal to that of *a* which is seen by the opposite eye. In each run the order of θ values was from large to small. Prior to each run, a set of data was obtained with the inhibiting stimuli removed from the field of view.

The data for two separate subjects are summarized in Tables II and III and are plotted in Figs. 8 and 9.

In order to compare this type of data with that shown in Fig. 7 values of glare index T were computed for the data shown in Fig. 9 in accordance with Equation (1).

The values of T for observer T. H. are summarized in Table IV. Values of T less than 0.1 have little meaning because of the indeterminateness of the data. It should be noted that the value of β_a was determined by making a binocular match between β_b and β_a when the glare sources are removed from the field. This makes the results independent of any imbalance which might exist between the

TABLE II.—Data for G.A.F. obtained with the stimulus pattern in Fig. 6 showing the effect of varying θ and β_e on the actual brightness of *b* required to make *b* match *a*. Brightness β_a of *a* constant. β_b and β_e are expressed in footlamberts.

	β_b						
	c and *c'*	θ					
β_e	Removed	0.75°	1°	1.5°	2.5°	3.5°	4.5°
2350.0	6.74	126.00	53.8	30.0	16.94	10.76	10.64
1245.0	6.34	65.0	32.7	22.3	15.78	11.5	9.42
558.0	7.34	47.5	21.4	13.04	8.96	8.68	8.2
335.0	5.83	33.0	17.3	12.95	7.95	6.6	6.95
223.4	6.48	30.1	14.94	11.0	7.77	6.66	6.52
111.7	5.78	19.3	10.2	9.14	7.08	7.63	6.3
55.8	5.46	11.48	9.6	8.16	7.3	6.14	5.98
27.9	6.24	13.3	7.66	6.06	6.56	7.02	5.34

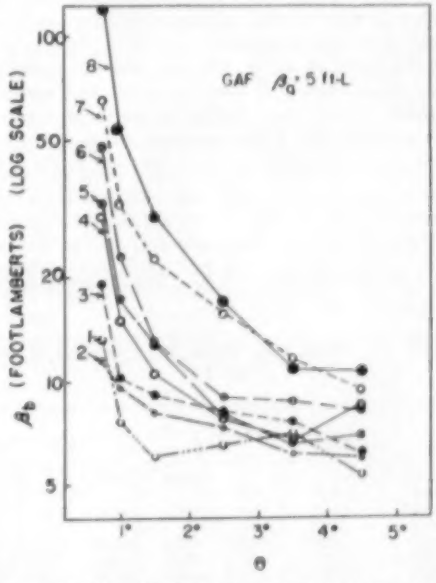

Figure 8. Results obtained by subject G. A. F. with the stimulus pattern shown in Fig. 6. The different curves represent different values of β_e in footlamberts as follows: 1 = 27.9; 2 = 55.8; 3 = 111.7; 4 = 223.4; 5 = 335; 6 = 558; 7 = 1245; 8 = 2350.

TABLE III.—Data for T. H. obtained with the stimulus pattern in Fig. 6 showing the effect of varying θ and β_c on the actual brightness of b required to make b match a in brightness. Brightness β_a of a constant. β_b and β_c expressed in footlamberts.

		β_b					
β_c	c and c' Removed	0.75°	1°	1.5°	2.5°	3.5°	4.5°
		θ					
6.65	5.81	5.04	4.93	6.28	6.46	5.74	5.5
16.63	4.71	5.84	5.23	4.7	4.66	4.73	5.1
33.25	4.73	9.06	8.38	7.36	6.3	6.06	5.74
66.5	5.07	8.94	6.06	5.26	4.8	4.89	5.54
166.3	4.68	7.12	5.8	5.16	4.84	4.95	4.80
332.5	4.67	9.68	6.7	5.46	5.1	4.92	4.64
665.0	4.74	13.2	8.54	6.56	5.73	5.28	5.4
1,663.0	5.12	22.6	16.06	11.32	8.74	8.56	6.98
3,325.0	4.75	18.74	11.34	9.14	7.68	6.08	5.08
6,650.0	4.76	35.6	25.5	20.26	15.04	9.96	7.04
16,630.0	4.73	62.2	42.2	28.6	18.62	12.46	9.82
33,250.0	5.36	95.4	64.6	40.4	31.8	20.18	15.92
74,100.0	5.6	684.0	91.8	58.8	39.4	30.0	18.24
139,900.0	5.47	—	678.0	107.6	99.8	58.2	30.0
Mean	5.0						

two eyes. The balance between the two eyes varies considerably from observer to observer and from one experimental session to another. A redetermination of β_a was made for each brightness level and these varying values of β_a were used in computing values of T.

Fig. 10 shows values of log T plotted against log β_c for various values of θ. The variation in the slopes of the best fitting straight lines may be dependent in part upon the variations in balance between the two eyes or a small error in the determination of β_a. If the variation in T were completely determined by stray light falling on the fovea, the slope of the line in these graphs as well as those in Fig. 7 should be the same.

By using the graphs in Fig. 10 to interpolate the data, one can determine for the various values of θ the value of β_c required to yield a constant value of T. In Fig. 11 are shown the values of β_c for different values of θ which are required for a value of T equal to unity. This means that the amount of stray light falling on the fovea is constant, and according to Fig. 4 the equivalent veiling brightness β_e is equal to 30 footlamberts. From the data in Fig. 11

$$\beta_c = \frac{\kappa \beta_c}{\theta^\nu} \tag{2}$$

where $\kappa = 0.00545$, and $\nu = 2.5$. The illumination at the eye E produced by the two glare sources is given by the following equation

$$E = \frac{\beta_c}{\pi}\,\omega \tag{3}$$

where ω is the solid angle (in steradians) subtended by the two rectangular glare sources, and where E is expressed in footcandles and β_c in footlamberts.

Since $\omega = 7.656 \times 10^{-4}$ steradians,

$$\beta_c = \frac{22.4\,E}{\theta^{2.5}}, \tag{4}$$

where β is expressed in footlamberts and E in footcandles.

It should be noted that the form of Equation (4) is identical with that of the equations used by Holladay,[4] and Stiles,[5] and Stiles and Dunbar[6] to express the relationship between the intensity of the glare source, the glare angle, and the equivalent veiling brightness. The values of the constants are also in reasonable agreement with those found by these investigators when allowance is made for the units used. The equation given by Stiles and Dunbar is

$$\beta_c = \frac{10\,E}{\theta^2} \tag{5}$$

where β_c is expressed in candles per unit area and E in lumens per unit area.

In the experiment described above, the beam of light entering the eye was confined to an area smaller than the pupil and was not affected by variations in pupil size. In

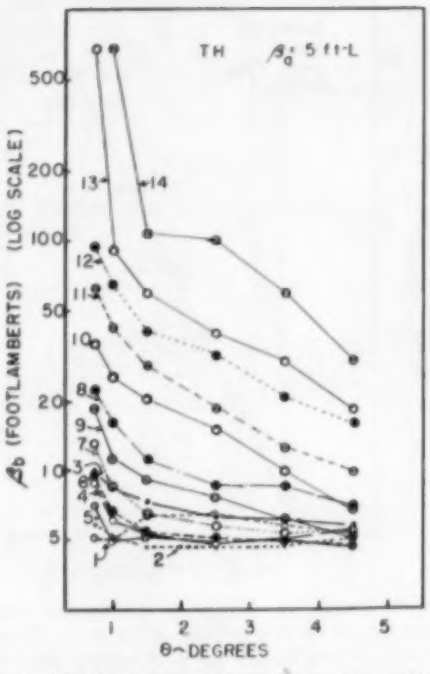

Figure 9. Results obtained by subject T. H. with the stimulus pattern shown in Fig. 6. The different curves represent different values of β_c in footlamberts as follows: 1 = 6.65; 2 = 16.63; 3 = 33.25; 4 = 66.5; 5 = 166.3; 6 = 332.5; 7 = 665; 8 = 1663; 9 = 3325; 10 = 6650; 11 = 16,630; 12 = 33,250; 13 = 74,100; 14 = 139,900.

TABLE IV.—Data from Table III expressed in terms of T.

	θ					
β_c	0.75°	1°	1.5°	2.5°	3.5°	4.5°
6.65	—	—	.0812	.112	—	—
16.63	.219	.1082	—	—	.0021	.0828
33.25	1.106	.762	.557	.333	.282	.214
66.5	.762	.195	0.41	—	—	.0927
166.3	.532	.1327	.1005	.0342	.0577	.0256
332.5	1.072	.435	.169	.092	.0557	—
665.0	1.76	.8	.384	.2062	.114	.139
1,663.0	3.41	2.13	1.21	.707	.6725	.363
3,325.0	2.95	1.36	.925	.617	.380	.0695
6,650.0	6.48	4.35	2.25	2.16	1.091	.479
16,630.0	12.13	7.94	5.09	2.94	1.632	1.074
33,250.0	16.82	11.04	6.53	4.94	2.76	1.97
74,100.0	121.0	15.36	9.49	6.04	4.26	2.26
139,900.0	—	122.8	18.9	17.25	9.63	4.46

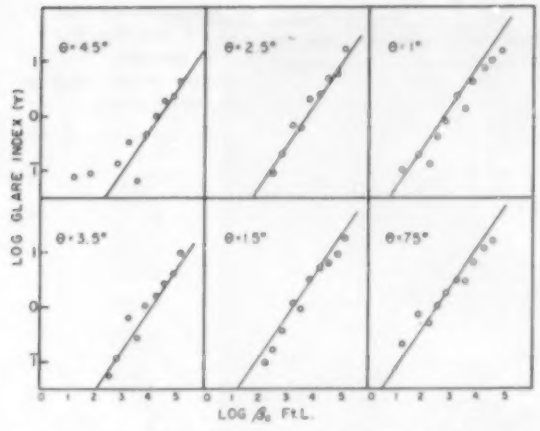

Figure 10. Results obtained by T. H. with the stimulus pattern shown in Fig. 6.

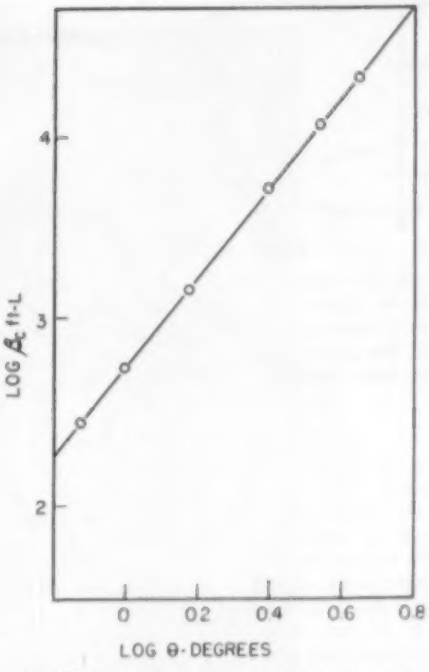

Figure 11. Values of β_c required to yield a value of unity for T for various values of θ. Data interpolated from the curves in Fig. 10.

this respect the experiment differs somewhat from those performed by the previous investigators. It should also be noted that the data presented by the authors are limited to glare angles from ¾ to 4.5 degrees, and the data presented by Stiles and Holladay[4] and Stiles and Dunbar[6] cover much larger glare angles.

B-3—*Changes in Foveal Sensitivity Immediately Following the Onset of a Glare Source* — Schouten and Ornstein[1] used the stimulus pattern shown in Fig. 12 for studying the changes in foveal sensitivity which occur immediately after the onset of a glare source. They exposed the glare source for various durations and during the last 10 milliseconds of this exposure also exposed *a'* and *b'*. The semicircle *b'* and the glare source were seen by the right eye, and *a'* was seen by the left eye. The brightness of *a'* was kept constant and that of *b'* was varied from exposure to exposure to make *b'* match *a'*. In this way they demonstrated that the sensitivity falls gradually during the first 200 milliseconds and after this remains constant. No overshooting occurs.*

The maintenance of a constant level after the first 200 milliseconds they designate as the *law of constant level.* This empirical law is of great theoretical significance in formulating and testing hypotheses concerning the mechanism subserving the effect, but the practical bearing upon the present investigation is that the finding of Schouten and Ornstein can be used as justification for using glare sources continuously exposed and making measurements without reference to the duration of exposure. Care has been exercised, however, in starting off each experimental session with the subject dark adapted and working always from the lower to the higher brightness levels.

B-4 — *Effects Obtained with Asynchronous Momentary Stimuli* — Schouten and Ornstein[1] used the stimulus pattern shown in Fig. 12 also to study the effects of a momentary exposure of the glare source. They exposed the glare source for 10 milliseconds and after an interval exposed *a* and *b* simultaneously for 10 milliseconds. They reported that the inhibitory effect of the glare source on *b* increases as the interval increases up to about 50 milliseconds and then decreases and disappears completely when the interval between the two stimuli is as long as 150 milliseconds.

Since the glare angle employed was 10 degrees it appeared to us that this effect might depend upon stray light superimposed upon the test object and its immediate surround. If this is true one should be able to produce the same effect with a patch of artificial stray light. In order to study this type of effect first hand, the stimulus pattern illustrated in Fig. 5 was employed. The artificial stray light *c* was presented for an exposure of 5 milliseconds, and at a certain interval of time prior to or succeeding this

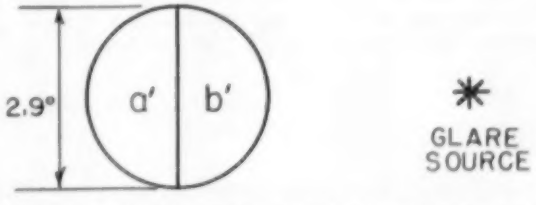

Figure 12. Stimulus pattern employed by Schouten and Ornstein.

*Schouten and Ornstein attached a great deal of significance to the fact that no "overshooting" occurs. This points to the possibility that the effect may be tied up with component III of the retinal potential as analyzed by Granit. However, if stray light falling on the fovea is responsible for the loss in sensitivity, one would expect this to be brought about by a lowering of the concentration of the photosensitive substance in the photoreceptors until this concentration reaches its equilibrium. No overshooting is to be expected in this process.†

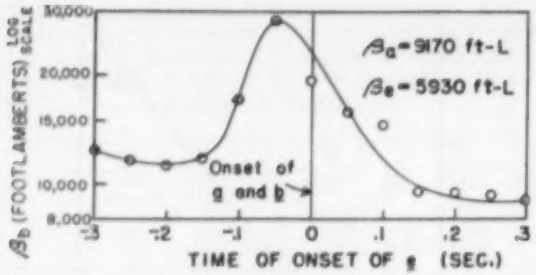

Figure 13. The effect of a synchronous exposure of *e* and *a-b* (Fig. 6). Zero on the time scale represents the onset of *a* and *b* which are exposed simultaneously for 5 milliseconds. The patch of veiling glare *e* is also exposed for 5 milliseconds. When *e* is turned off, *b* matches *a* when β_b = 9170 footlamberts.

TABLE V.—The effects on τ of asynchronous flash (5 milliseconds exposures of *e* and *a-b* (see Fig. 6). β_e = 5930 footlamberts. β_a constant. β_b varied from one cycle of exposures to the next to obtain a match with *a*. β_b in footlamberts.

	milliseconds	β_b
No veiling glare		9,170
e precedes *a-b* by	300	12,510
	250	11,800
	200	11,220
	150	11,700
	100	17,200
	50	28,290
e and *a-b* together		19,400
e follows *a-b* by	50	15,800
	100	14,630
	150	9,570
	200	9,550
	250	9,410
	300	9,200

exposure of *e*, *a* and *b* were exposed simultaneously for 5 milliseconds. This cycle of exposures was repeated once every three seconds. The effect of *e* upon *b* was determined by varying the brightness of *b* to make it match *a* in brightness. The subject started with the brightness of *b* at a level which made it appear brighter than *a* and from one cycle to the next reduced the brightness of *b* until it appeared to match *a*. He then started with a brightness of *b* which made it appear darker than *a* and increased the brightness of *b* to obtain a match. This procedure was repeated three times and an average of the six settings was taken as representing a match.

Similar matches were made for other time intervals between the exposure *e* and the exposure of *a* and *b*. The results are shown in Fig. 13 and are summarized in Table V.

It should be noted that after 300 milliseconds the retina is just recovering from the veiling glare. The maximum inhibitory or adaptation effect occurs when the glare source precedes the test object by 50 milliseconds. It should be noted also that the veiling glare can affect the test object even when it follows the test object by as much as 100 milliseconds. A similar effect upon the threshold of visibility has been noted by Crawford.[8]

Appendix C.—Analysis of Recovery from Indirect Adaptation

Schouten and Ornstein[1] showed that the rate of recovery from adaptation to a peripheral glare source depended upon the length of exposure of the eye to the glare source in spite of the fact that the inhibitory effect reaches a constant level 200 milliseconds after the beginning of the exposure and retains this level during the rest of the exposure. They showed that the effects were analogous to those obtained by direct adaptation.

As a matter of fact, it is possible from the data presented in Figs. 9 and 10 in their paper[1] to show that the recovery curve following direct adaptation for 60 seconds to a surface having a brightness of 270 c/m^2 (79 footlamberts) would be approximately the same as the recovery curve following indirect adaptation for 60 seconds to a glare source at a glare angle of three degrees and producing an illumination of 130 lux (12 footcandles) at the eye.

According to Equation (5), a glare source at a glare angle of three degrees and producing an illumination of 12 footcandles at the eye should produce an amount of stray light equivalent to a veiling brightness of 42 footlamberts. This calculated value is close enough to the empirical value of 270 c/m^2 (79 footlamberts) to lead one to suspect that indirect adaptation is dependent upon stray light falling on the fovea.

If this is true, the mechanism of adaptation is essentially the same in both direct and indirect adaptation and can probably be explained in terms of the primary photochemical mechanism in the photoreceptors.

Appendix D.—Effect of Wavelength Composition

Schouten and Ornstein[1] and Ivanoff[9] have investigated the effects of varying the wavelength composition. If the effects are dependent indirectly upon stray light in the eye, the differential reflectance of the retina and the differential transmittance of the sclera and choroid for the various wavelengths would contribute to the variations that have been found.

References

1. J. F. Schouten and L. S. Ornstein: *Journal of the Optical Society of America*, 29, 168-182 (1939).
2. G. A. Fry and M. Alpern: *J.O.S.A.*, 43, 187-188 (1953).
3. G. A. Fry and M. Alpern: *Am. J. Optom.*, 31, 506-520 (1954).
4. L. L. Holladay: *J.O.S.A.*, 12, 271-319 (1926).
5. W. S. Stiles: *Proc. Roy. Soc.*, B 104, 322-351 (1928-29).
6. W. S. Stiles and C. Dunbar: Illum. Res. Comm. (Great Britain) Tech. Paper No. 16 (1935).
7. G. A. Fry and M. Alpern: *Am. J. Optom.*, 23, 509-525 (1946).
8. B. H. Crawford: *Proc. Roy. Soc.*, B 134, 282-302 (1947).
9. A. Ivanoff: *Revue d'Optique*, 26, 479-488 (1947).
10. P. Moon and D. E. Spencer: *J.O.S.A.*, 33, 444-456 (1943).
11. P. Moon and D. E. Spencer, *J.O.S.A.*, 35, 233-248 (1945).
12. G. A. Fry and M. Alpern: *J.O.S.A.*, 43, 189-195 (1953).

INSTALLATION AT ST. CLAIRE BARBER SHOP
88 WEST SAN CARLOS STREET, SAN JOSE, CALIFORNIA

Lighting a Barber Shop

LIGHTING OBJECTIVE: To provide general illumination and supplementary lighting on the backs of the heads of customers seated in the barber chairs.

GENERAL INFORMATION: The shop is 13 feet wide, 36 feet long and 18 feet high. The interior is decorated as follows:

ceiling	dark green	12% RF
wall		
top 6 feet	dark green	12% RF
bottom 12 feet	light green	54% RF
floor		
working area around barber chairs		10% RF
customer waiting area		31% RF

INSTALLATION: Three Sunbeam No. L1504-72SL louvered luminaires each with four 72T12 standard warm white slimline fluorescent lamps operated at 430 ma are mounted on the center-line of the room 8 feet 6 inches above the floor. Fig. 2 shows the special barber shop unit (built by Haluk Lighting Mfg. Co., San Francisco) consisting of two 96-inch sections and one 72-inch

(over)

A.I.A. File No. 31

section (overall length 23 feet 6 inches) which is installed above the mirror frame 7 feet 6 inches above the floor. Each section of this unit contains two standard warm white lamps. This unit lights the back of the customers' heads.

The illumination after six months' operation averaged 51 footcandles on the counter and 56 footcandles at head level at the barber chair. Brightnesses are as follows:

wall	20	ft-L
floor		
working area around barber chairs	4.7	ft-L
customer waiting area	13.3	ft-L
shelf	21	ft-L
white cloth covering customer	53.5	ft-L
hair of average customer	53	ft-L
trough lighting unit (as seen by barber)	810	ft-L
general lighting unit (30° lengthwise)	455	ft-L

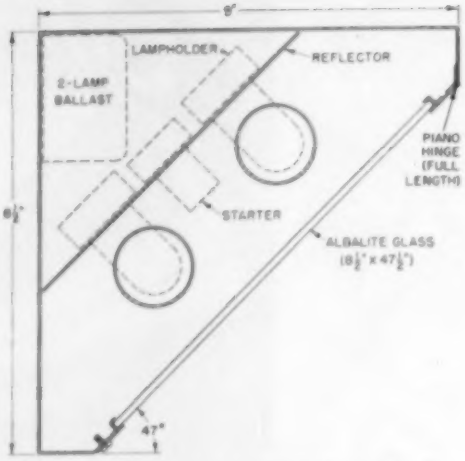

Figure 2. Section of custom-built trough lighting unit. (Not to scale.)

Lighting designed by Mr. Marion G. Herbert, Professional Engineer, San Jose, California.

Lighting data submitted by Vernon H. Lind and George E. Baker, Pacific Gas and Electric Company, San Jose, California as an illustration of good lighting practice and to aid in the design of similar installations.

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Xenon Short Arc Lamps and Their Application

Discussion of paper by W. E. Thouret and G. W. Gerung

(Published November 1954 ILLUMINATING ENGINEERING)

THEODORE H. PROJECTOR:* Users of searchlights and other lighting equipment characterized by very precisely controlled beams and by sources of high brightness are very much interested in the new line of xenon short arc lamps. The lamps discussed in this paper, with brightnesses up to 250 candles/sq mm, do not reach the brightnesses of modern carbon arcs, which are as high as 800-1200 c/sq mm in conventional high intensity lamps and reach values of 2000 c/sq mm in experimental water-cooled types. Nevertheless, compared with incandescent lamps, they offer greatly increased brightness while retaining freedom from mechanical auxiliary equipment. Xenon lamp economics are an impediment to their use in many applications where their other qualities are attractive, but increased lamp life may minimize the importance of this factor. Finally, in many applications where frequent changing of carbons is impractical, the xenon compact arc source may offer the optimum combination of desirable characteristics.

I believe therefore that the new line of xenon lamps, although somewhat limited in its application, nevertheless, is a promising and already useful addition to the list of high brightness light sources and further development along the lines indicated will greatly increase its importance.

A. G. PENNY:** I should report that the development of xenon compact source lamps in Britain has proved somewhat disappointing. By 1950 we had reached the stage where lamps up to 5 kw could be produced on a commercial scale — see for instance the article by E. F. Edwards, *Electrical Review*, London, March 1950 — but to date the applications have been limited entirely to what might be called specialized laboratory use.

Our previous work on mercury and mercury-cadmium lamps had shown that although the latter were suitable for film studios making color films, they had not a properly balanced spectrum for the projection of color films. Xenon lamps, on the other hand, had quite a satisfactory color as the authors have demonstrated today. Unfortunately we found that the economics of xenon lamps as compared with other sources were quite unsatisfactory — a situation which still obtains.

We studied the use in 35 mm projections but were forced to the conclusion that lamps of between 2½ kw and 5 kw were required to compete with the ordinary 60-ampere arc and that such lamps would have to have a life well in excess of 1000 hours, if the running costs were to approach those of the carbon arc.

In the case of 16 mm projection the well known inadequacy of the tungsten lamp for larger audiences encouraged us but we have found that the 1 kw carbon arc is considered by projector makers as a more straightforward method of reaching high screen lumens. Contrary to the general belief the carbon arc is now a relatively simple unit of good reliability and easily operated by non-technical people and the servicing of such apparatus is well established.

The operation of xenon lamps on a-c, which is almost a necessity for 16 mm projectors as it is rarely worthwhile to install d-c, introduces a number of problems and I am interested in the system described by the authors. It sounds very promising if adequate lamp life can be obtained. Similar ideas in Britain have not so far proved attractive to projector manufacturers partly because synchronization between lamp and shutter on 50-cycle supplies involves running the film at 25 frames per second instead of the normal 24 frames per second. Information regarding the operating wattage of the lamp and the resultant screen lumens with shutter running would be interesting.

H. U. HJERMSTAD:* I believe that the xenon short arc lamp holds possibilities as a high brightness light source. One of the difficulties of this light source, however, is the terrifically high starting voltages that are necessary in order to bring about voltage break-down of the lamp, and ballasting of this lamp becomes a major problem.

In Table I on page 521 (November 1954 I. E.), no mention is made of the necessary open circuit voltage required in order to maintain the indicated lamp arc voltages. With a 20-24 volt arc drop the ballast with the circuit shown on page 524 would be required to ballast approximately 100 volts. I wonder if enough information is at hand to establish the minimum open circuit ballast voltage in order to maintain the arc.

On page 524 it is mentioned that the break-down voltage of the high voltage pulse circuit lies in the range between 10 and 50 kilovolts. Can these limits be set more closely? I wish that the authors could elaborate further on this spark oscillator. What troubles if any have resulted from a starting circuit of this type, that is, radio interference and rapid deterioration of the spark gap which would require considerable maintenance?

F. R. JEFFREY:** What is the maximum possible elapsed time between pulses of light?

W. E. THOURET and G. W. GERUNG:† The authors are in agreement with Mr. Projector that the presently available xenon lamps cannot replace high intensity carbon arcs in large searchlights, where wattages of 5 kw or more and extremely high brightness are required. However, xenon lamps will probably be useful in smaller searchlights under certain conditions, *e.g.*, when a minimum of maintenance or both visible and invisible radiation are desired.

Mr. Penny's report on the development and experimental use of xenon short arc lamps in Britain is very interesting. As the authors have mentioned briefly in the paper, they are fully aware of the fact that at present the replacement of carbon arcs for 35 mm movie projection by xenon lamps presents an economic problem. Considerable further development work toward cost reduction and increase of life of the xenon lamps will be required before this problem can be solved. For 16 mm motion picture projection, however, the xenon lamp in its present state of development seems to be definitely useful and progressive in comparison to incandescent filament projection lamps.

In this country there is a growing trend toward the use of larger screens and Cinemascope projection also for 16

*National Bureau of Standards, Washington, D. C.
**General Electric Co., Ltd., England.

*Sola Electric Co., Chicago, Ill.
**Crouse-Hinds Co., Toronto, Ont.
†Authors, Westinghouse Electric Corp., Bloomfield, N. J.

mm film. Therefore, a considerable increase in the available amount of screen lumens is required. The two methods of solving this problem are: (1) to increase the brightness of the incandescent lamps or (2) to use carbon arc lamps. Increasing the brightness of incandescent lamps would reduce their life to less than ten hours without significant gain in brightness and would render their use rather uneconomical. Carbon arcs still seem to require considerable development before they can be used as conveniently and as maintenance-free as xenon lamps.

E. W. D'Arcy and A. C. Seda have demonstrated in a recently published paper[1] that the xenon lamp is a perfect intermediate source between filament lamps and carbon arcs for 16 mm projectors. In their new projector for the Armed Forces they utilize not only the higher brightness of the xenon lamp but also its unique characteristic that its light output can be pulsed electrically in such a manner that the lamp itself acts as a shutter. Thus a 1000-watt xenon lamp produces more than four times the screen lumens of presently used projectors with 1000-watt ten hour life filament lamps.

With regard to Mr. Hjermstad's questions:

The necessary open circuit voltage required for existing starting and ballasting circuits is approximately 120 volts. However, when the lamp is in operation it only requires a line voltage or open circuit voltage of approximately twice the arc voltage. Therefore, if necessary, it would be possible to start the lamp at a higher voltage and switch over to a lower voltage during operation to eliminate the high ballasting voltage required. With regard to the starting circuit itself the high voltage pulse of between 10 to 50 kv, it is rather difficult to define more clearly since the measurements of such a voltage requirement are not easy to make and the energy requirement will vary with different lamp types.

Under normal operation the present starting circuits only produce objectional radio interference when the lamp is started. In most applications no difficulty has been encountered by this momentary interference. In applications where even this small amount of intereference is objectionable line filters would be required. Spark gap maintenance has been practically eliminated by using multiple gaps with large surface areas. Where necessary magnetic quench type gaps have been designed.

With regard to Mr. Jeffrey's question of what is the maximum possible elapsed time between pulses of light, it can be stated that at frequencies up to several hundred cycles per second the light output of the xenon arc follows the electrical input virtually without delay. Thus the dark intervals between pulses, the duration and the intensity of pulses are entirely defined by the characteristics of the eletrical supply and the ballasting circuit.

1. Journal of the Society of Motion Picture and Television Engineers, Vol. LXIII, p. 99. 1954.

MODERN lighting system was planned for Carey's, luggage store in Elmira, N. Y., to harmonize with the decor, achieve comfortable high levels of illumination, and bring out the sales-appealing colors and grains of quality leather.

General illumination is from 10 x 10-foot panel units, with 2-foot-square Albalite glass panels, providing approximately 100 footcandles maintained on the sales tables. Lamps are spaced on 12-inch centers. Highlighting of specific counters and products is with rows of recessed, lens-shielded 150-watt incandescent units.

Illuminating engineer: Larry Sweetland, New York State Electric and Gas Corp.; electrical distributor: LeValley-McLeod; contractor: C. H. & J. T. Kelley Electric. all of Elmira, N. Y.

Graphical Representation Of Utilization Data

By ROBERT D. BURNHAM

WHEN FIGURES are presented they can be no more accurate than their means of computation. Since errors are accumulative, it is irrelevant whether error is introduced into measurement at the laboratory, in computation, in presenting data, or in its application. Like the proverbial chain with a weak link, the result cannot be more accurate than the least accurate operation.

It is axiomatic that the more references and calculations handled the greater likelihood of error. The semi-graphical method of calculating illumination shown here was developed primarily to eliminate as many possible sources of errors.

It provides:

1. A greater accuracy as compared with tabular form since interpolation is more easily carried out.
2. Consolidation of data to one graphical sheet eliminating the need of referring to a number of sources — lamp lumen output, room index, coefficient of utilization, or utilization factor and luminaire efficiency.
3. To simplify final calculations.

AUTHOR: Illuminating Engineer, The F. W. Wakefield Brass Co., Vermilion, Ohio.

The lumen method equation can be divided into sections.

$$E \text{ initial} = \frac{N_f \times L_l \times N_l \times e \times UF}{A}$$

$$= (N_f)\ (L_l \times N_l \times e)\ (UF/A)$$

Let: Luminaire constant $= L_l \times N_l \times e$

and Room coefficient $= UF/A$

then E initial $= N_f \times$ luminaire constant $\times$ room coefficient

where N_f = Number of luminaires

L_l = Lumens per lamp

N_l = Number of lamps per luminaire

e = Luminaire efficiency

UF = Utilization factor (interflectance)

A = Room area

The luminaire constant is peculiar to each individual luminaire design, and the lamps with which it is equipped. Therefore, a constant figure can be associated with each luminaire.

The room coefficient is more complex and relies upon the room configuration, luminaire distribution and the reflectance of its principal surfaces. This factor can be determined in four steps, the room index excluding ceiling height, room index, utilization factor and utilization factor divided by

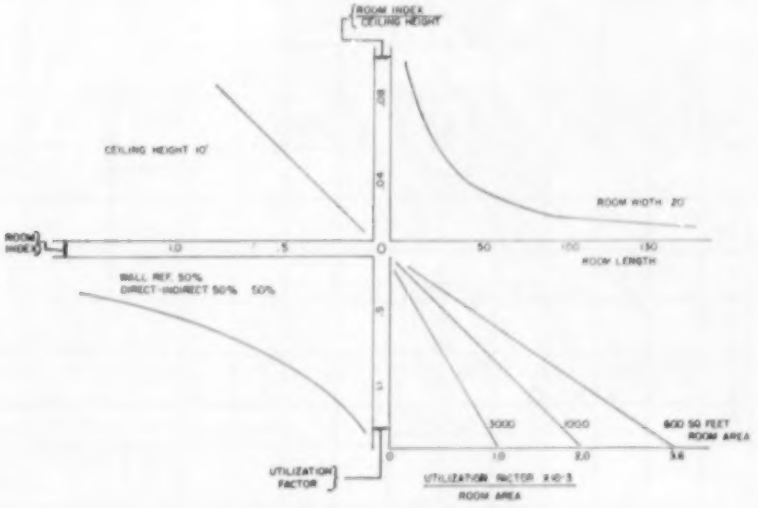
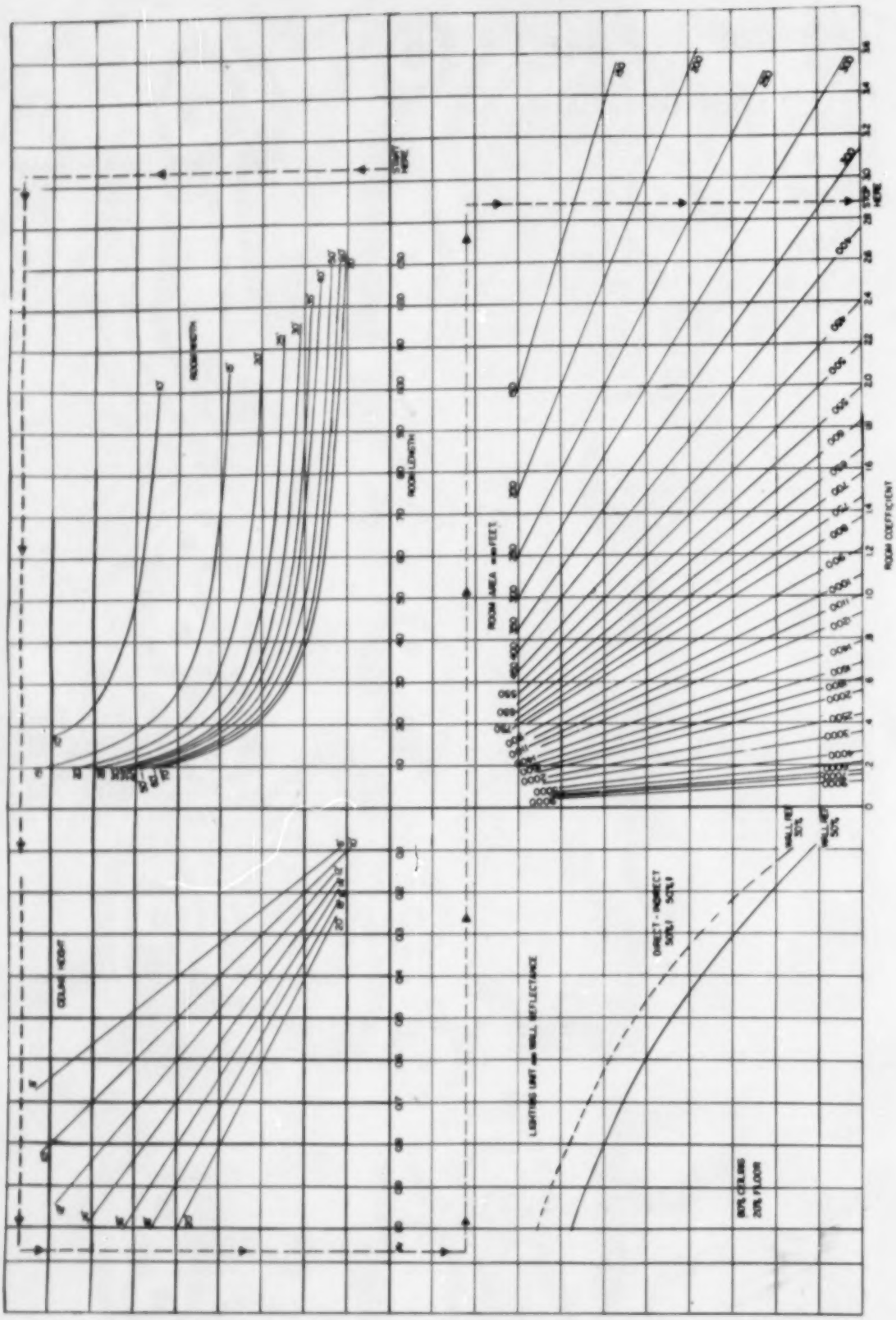


Figure 1. The four individual graphs are joined together in this manner to make a continuous graphical procedure.


ROOM COEFFICIENT
ROOM AREA in SQUARE FEET
ROOM LENGTH
LIGHTING UNIT and WALL REFLECTANCE
DIRECT - INDIRECT
50% CEILING
20% FLOOR

←

Figure 2. (on facing page) A quadralux diagram for a direct-indirect fluorescent luminaire. Starting at the room length coordinate, progress upward to room width, left to ceiling height, down to wall reflectance, right to room area and down to room coefficient.

room area. It now becomes evident that four families of graphs could provide this solution — room coefficient, and since there would be three common axes they may be placed together in the form shown in Fig. 1.

These "quadralux" graphs may be derived to represent utilization data regardless of the method, be it Harrison-Anderson or interflection. Fig. 2 shows a typical representation for the interflection method as interpreted by Innis.[2] As many luminaire types and wall reflectances as desired could be added in the third quadrant. For simplicity, only one luminaire type and two wall reflectances are represented, ceiling and floor reflectances are considered constant. As an approximation a proportional change in room coefficient may be used with different ceiling reflectances.

The room coefficient is determined by following a counter-clockwise direction around the graph, starting at the room length abscissa and terminating at the room coefficient abscissa. The dotted line acts as a guide path. At each quadrant, the pertinent room width, ceiling height, luminaire type-wall reflectance and room area are chosen.

One "quadralux" diagram can replace an untold number of coefficient of utilization tables. The limiting factor is the point where confusion may be introduced by the addition of more luminaire curves in the third quadrant. Color coding the curves has been found to be useful at this point.

A by-product of those curves is a rapid means of determining room index, hence the left-hand abscissa is the K_r scale. Termination at this point, yields a numerical room index.

The luminaire constant is usually a factor of several thousand, while the room coefficient is usually several thousandths, so to keep these factors in the range of from $^1/_{10}$ to 10 the luminaire factors are tabulated as the actual value times 10^{-3}, and the room coefficients are multiplied by 10^3. This, of course, cancels out in the final calculation and is only of concern when the "quadralux" diagrams and luminaire constants are being prepared.

As an example, consider a room 30 ft. x 40 ft. with a 12-ft. ceiling. Assume the wall reflectance at 50 per cent, a white ceiling 80 per cent and 20 per cent floors. The room coefficient .61 is determined for a louvered direct-indirect luminaire. The luminaire constant is found in Table I. Now the initial illumination can be calculated, assuming twelve 8-ft. two-lamp luminaires are to be used.

E (initial) = number of luminaires × luminaire constants × room coefficient

$= 12 \times 8.30 \times .61 = 60.7$ footcandles

TABLE I.—Louvered, 2-Lamp, Direct-Indirect Luminaire.

41.5% / 41.5% Lamps	Luminaire Constant
40-Watt, T-12 Rapid Start or Preheat	4.15
74-Watt, T-12 8 ft Slimline	8.30
36-Watt, T-12 4 ft Slimline	3.81

This solution checks closely with the coefficient of utilization method solution since they are identical, the difference being only in the method of data presentation.

Conclusion — A semi-graphical means of calculating illumination is described. Existing data are used to provide a series of graphs allowing a more accurate and less complex mathematical attainment of average predicted illumination levels in interiors.

Bibliography

1. *IES Lighting Handbook*, Second Edition, p. 9-2, Illuminating Engineering Society, New York, N. Y. (1952).
2. Innis, L. E.: "Interflectance Tables from Conventional Photometric Data," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 11, page 595 (November 1953).

invites you in '55

I.E.S. NATIONAL TECHNICAL CONFERENCE

September 12-16

Platform — Before, above, and after, below.

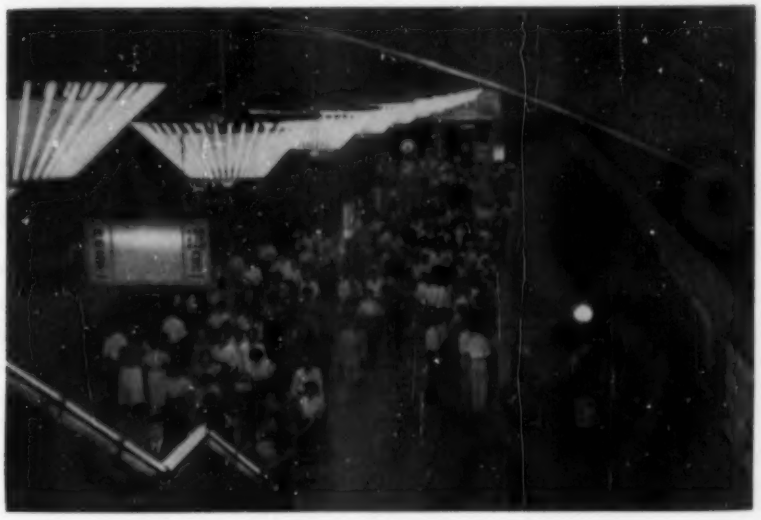
Subway Lighting

In New York City . . .

As a first step toward "doing something" about the lighting in New York City's subway stations, a fluorescent system has been installed in the IRT Grand Central subway station and platforms. Illumination level jumped from 0.6 to 8 footcandles when the switch was pulled turning on the new fluorescent lighting. The six-foot-long acrylic plastic luminaires are installed in continuous rows at the edge of the subway platforms; and upstairs, in the station, where the units are spaced at regular intervals they are used also for directional signs — "To Uptown (or Downtown) Trains," "To Times Square and West Side Subway."

Directional signs which point the way to the Shuttle to the West Side Subway, will continue in service after the Shuttle has been replaced by proposed conveyor belt.

Re-lighted station, in the background, contrasts with the gloomy tunnel, in the foreground, which still employs the old lighting system.



. . . and in Osaka, Japan

On the other side of the world, subway lighting has been receiving much thought in Osaka, Japan. New fixtures have been designed their shape inspired by a traditional and loved symbol from Japanese culture — with sound engineering principles also behind its choice.

The eleven chandelier-type luminaires, shown here in the Shinsaibashi station platform, are hung at a height of 16 feet from the 22-foot ceiling. Each is composed of 42 40-watt deluxe white fluorescent lamps arranged in the shape of a circular cone, inspired by the design of the *karakasa* (Japanese umbrella) with which Japanese girls dance the *sagimusume, shiokumi,* and other traditional dances.

The purpose of the conical shape is not only for such decorative scheme, but also for effective utilization of luminous flux. The lamps are arranged at an angle of 45 degrees, with luminous flux intersecting at any height to provide good vertical illumination on station name signs, shapes and colors of columns advertising sign-boards, etc. Since one method of identifying stations is by the different colors and shapes of tiles and platforms, this vertical illumination is considered important.

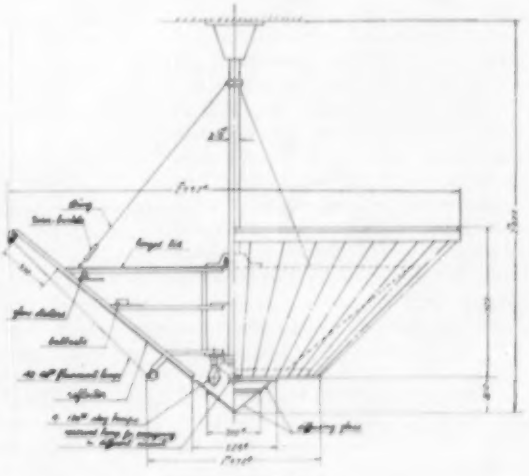
Measured horizontal illumination in the Shinsaibashi station averages 35 footcandles.

Behind the lamps are reflectors made of aluminum plates enamelled with vinyl-acetate acrylic copolymer paints at high temperatures. The reflectors do not extend to the top of the luminaire, allowing upward light to the station ceiling. Ballasts, starters and switches are installed on concentric circular frames (see drawing).

At the opening at the tip of the cone, four 120-watt "sky-lamps," mercury discharge and incandescent filament, are installed behind diffusing glass.

J. Sudo, technical designer, and Y. Nakajima, decorative designer, of Asahi Electric Co., were in charge of this installation.

Illustrations and data are courtesy of Mr. Sudo.



Detail of luminaire.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of H. F. Davidson, has prepared this table to answer a question from the American Society of Heating and Air-Conditioning Engineers. Readers are invited to submit similar questions of general interest on light sources. Questions may be sent to Society headquarters.

What is the overall wattage of fluorescent lamps and their auxiliary equipment?

Nominal Watts	Length, inches	Diameter, inches	Operating Current, ma	Watts Consumed: Lamp	Ballast	Total
			PREHEAT STARTING LAMPS			
20	24	1½	370	19.6	4.5	24.1
30	36	1	355	30.0	9.0	39.0
40	48	1½	425	39.6	8.8	48.4
85	60	2⅛	1620	84.0	17.5	101.5
90	60	2⅛	1550	90	17	107
100	60	2⅛	1520	101	16	117
			RAPID STARTING LAMPS			
40	48	1½	430	39.5	9.0	48.5
			INSTANT STARTING HOT CATHODE LAMPS			
	42	¾	120	18	8	26
			200	25	10	35
			300	33	12	45
40*	48	1½	425	40	11-15	51-55
	48	1½	427	38	11-15	49-53
40**	60	2⅛	420	40-43	11-14	51-57
	64	¾	120	27	11	38
			200	37	14	51
			300	51	18	69
	72	1	120	26	11	37
			200	37.5	14	51.5
			300	51	18	69
	72	1½	425	55	14-16.5	69-71.5
	96	1	120	34	14	48
			200	49	14	63
			300	69	21	90
	96	1½	425	73	16-20	89-93
			COLD CATHODE LAMPS			
(type LP)	96	1	120	43	8	51
(type HP)	96	1	100	42	11	53

*Bipin.
**Low brightness

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Council Meeting in New York; Summary of Action Taken

The second bi-monthly meeting of this year's IES Council was held in New York City December 9, with the following members represented: Duncan M. Jones, President, presiding. R. F. Hartenstein and M. N. Waterman, Vice-Presidents. Kirk M. Reid, General Secretary. G. J. Taylor, Treasurer. A. H. Manwaring and E. M. Strong, Past-Presidents. C. C. Shotwell, W. A. Stannard, J. F. Whitehead, and F. C. Winkler, Directors. Regional Vice-Presidents present were M. B. Hastings, C. W. McCormick, C. J. Berry, Glenn Park, A. C. Sangster, with S. H. Hazleton and C. C. Keller serving as proxies. Present also were A. D. Hinckley, Executive Secretary, Ruby Redford, Editor, C. L. Crouch, Technical Director, C. E. Ellis, Advertising Manager; and Willard Allphin, George Korten, Paul Hildebrand, S. G. Hibben, L. R. Anderson, J. S. Schuchert, R. M. Zabel, A. A. Brainerd, A. S. Turner.

In addition to regular reports and discussion on the Society's financial affairs, confirmation of committee appointments, and other business, action was taken on other items brought up for discussion.

Members Elected

On recommendation of the General Board of Examiners, two Members were elected and eight Associate Members transferred to Member grade. The Board reported their election and/or reinstatement of 99 Associate Members and 13 Students. Current membership figures were shown to be:

September 30, 1954		December 9, 1954
7902	Total Membership	8037
34	Members Emeritus	36
78	Fellows	78
1939	Members	1958
5621	Associate Members	5745
230	Students	220

Norman D. MacDonald, recently retired from Electrical Testing Laborntories, Inc., was unanimously elected to the grade of Member Emeritus of the Society. Mr. MacDonald has been a member of I.E.S. continuously since 1908, serving in many national offices and on numerous committees.

Two New Sections

Favorable action on a petition submitted through Marshall Waterman by James R. Chambers, Midwestern Regional V-P, changed the status of the Indiana Chapter, to Section.

Section status was also granted to the Florida Chapter, on petition presented by Glenn Park, Southern Regional V-P. Mr. Park noted this group was host to the forthcoming Southern Conference in Clearwater, Fla.

New Chapter

Charter for a new IES group in Oklahoma City was approved following successful petition, sent by J. M. Myers, Regional V-P, from the Oklahoma City Study Club. This active group, to be known as the Central Oklahoma Chapter, has held outstanding meetings with large attendance for some time. The Oklahoma Chapter in Tulsa petitioned for a change of name, because of its similarity to the new Chapter's, and pending further study the matter will be on Council agenda.

Regional Activities

Recommendations, and extensive discussion, were given to a number of other regional matters. Chief among these was national Society participation in Regional Conference plans, programs and finances. Full accord was given to the wish to strengthen these important conferences all possible.

New Region Proposed

Proposals for major boundary changes were outlined in detail for the Southern Region. Following study by a special three-man committee, Glenn Park, V-P, suggested division of this region into two, forming an additional Region of IES. After full discussion, action was taken to divide the Southern Region by a north-south line as of October 1, 1955. A Regional Vice-President will be appointed for a one-year term for the new region thus formed on the western section of the present Southern Region, pending final boundary decisions.

Regional Vice-Presidents present reported individually on recent activities in their Regions. A. C. Sangster (Great Lakes) noted that the 1956 Regional Conference will be in Grand Rapids. C. M. Berry (East Central) told details of a special meeting of Section/Chapter chairmen held in Baltimore. Actions there included a nominee for Regional V-P, planning of the 1956 conference for Reading, Pa. C. W. McCormick (Northeastern) reported extensive plans underway for the 1956 national technical conference in Boston, which will commemorate the Society's 50th anniversary.

Committee Reports

Letter ballot approval of Lighting for High Bay Areas was reported.

Fiftieth Anniversary general plans were discussed by S. G. Hibben, chairman of the Historical Committee. He especially recomended early development of a suitable anniversary emblem to be used in numerous ways during 1956.

J. S. Schuchert gave a progress report on the Society's publications program, noting especially plans for a special Anniversary issue of Illuminating Engineering, now scheduled for January 1956.

R. M. Zabel, chairman of the Papers Committee reported a number of changes in procedure resulting from a meeting of this committee December 1. Policy recommendations advanced included: Tape recordings of discussions. Friday (of conference week) to be reserved exclusively for committee meetings. No such meetings to be scheduled during session hours. Fewer papers per session, and more discussion. More parallel sessions. Continuation of invited special programs, similar to the "environment session" at Atlantic City. Lighting and architecture is suggested for this year.

Current activities of the technical committees were reported by C. L. Crouch, Technical Director.

Future Council Meeting

By majority vote of Council members, the April meeting of Council will be held in Phoenix, Arizona, preceding the Inter-Mountain Regional Conference there.

Technical Committee Forum Meets in Dearborn, Michigan

The fifth annual forum meeting of chairmen of IES technical committees was held November 16 and 17 at the Dearborn Inn, Dearborn, Mich. R. F. Hartenstein, I.E.S. Vice-President and Chairman of the Technical Committee Forum Committee presided. IES President Duncan M. Jones gave the opening address. Each committee chairman reported on his committee's progress to date and anticipated activities for the coming year, and there was considerable discussion of mutual problems. Featured speaker was Floyd Sell, of Detroit Edison Co., who showed slides illustrating unique solutions to difficult lighting problems. The group had a special tour of Edison's Menlo Laboratory at Greenfield Village and the Light's Diamond Jubilee exhibits at the Henry Ford Museum. At the dinner session Professor Russell Putnam described his visit and showed slides of his recent trip to Japan. Dr. Sylvester Guth likewise recounted his visit to Iceland.

The challenge and inspiration of the two-day session was so great that it was decided unanimously to continue this annual meeting.

ATTENDING the Technical Committee Forum in Dearborn, Mich., are, left to right, seated: Merle Keck, William H. Smith, Priscilla Presbrey, Franklin Dean, Kirk Reid, C. L. Crouch, R. F. Hartenstein, Duncan Jones, Eve Freyer, S. K. Guth, H. R. Blackwell; standing: Murray McDavitt, W. P. Lowell, G. K. Glass, H. F. Davidson, A. A. Sobolik, John Neidhart, A. W. Krawcek, Walter Sturrock, Robert Goodman, R. C. Putnam, Willard Allphin, Walter Granville, R. C. Allison, Benjamin Benson, Floyd Sell, Charles Rex.

U. S. Committee of CIE Holds Annual Meeting

The last annual meeting of the U. S. National Committee of the C.I.E. before the 1955 Zurich meetings of the International Commission on Illumination was held November 4 and 5 at the Nittany Lion Inn, in State College, Pa.

Much of the business before the 26 members of the Committee who attended was concerned with plans for the CIE sessions next June. Reports being prepared for Secretariats assigned to this country were reviewed, as were those of representatives assembling United States information for Secretariats assigned to other countries.

A preliminary survey indicates that a delegation of from 20 to 25 will attend the Zurich meetings from the United States. Through the Papers Committee, H. H. Magdsick, Chairman, six U. S. papers have been submitted for approval for presentation. These are:

Review of Visual Research — C. L. Crouch.
Subjective Additivity of Sources of Brightness — S. K. Guth.
Visual Performance — H. R. Blackwell.
Physiological Basis of Disability Glare — G. A. Fry.
Photometry of Fluorescent Lamps — E. H. Salter, A. W. Weeks, and R. G. Slauer.
Museum Lighting — Laurence Harrison.

A dinner meeting was held on the evening of November 4, with Vice-President Willard Brown serving as toastmaster. In keeping with the international purpose of the assemblage, the four talks had an international flavor. Dr. S. G. Hibben spoke on CIE conferences and about what our delegates may expect to see in Zurich; Professor W. A. Hedrich discussed lighting education in Germany, Austria, Switzerland and the Netherlands; Professor R. C. Putnam gave an illustrated description of his experiences in Japan, and Dr. S. K. Guth described his recent trip to Iceland.

Other highlights of the two-day meeting were the reports of President Arthur A. Brainerd, Secretary L. E. Barbrow and Treasurer T. D. Wakefield.

IES Represented at ECPD Conference

The 22nd Annual Meeting of the Engineers' Council for Professional Development in Cincinnati, Ohio, was a two-day conference held October 28-29 at the Hotel Alms, Cincinnati. At the request of IES President D. M. Jones, Beattie M. DeLong, Chairman of the Ohio Valley Section, represented the Society at the annual dinner meeting. Chief speaker at the banquet was James H. Taylor, Assistant Director for Manpower, Office of Defense Mobilization, and Director of Industrial Relations for Procter and Gamble Co., who spoke on "The National Manpower Outlook from the Point of View of the Professions."

Two-Day Illumination Institute Held at University of Wisconsin

An institute on illumination, for architects, builders, plant engineers, lighting consultants, and utility representatives, was held December 13 and 14, at the New Engineering Building, at the University of Wisconsin, Madison, Wis. Sponsored by the University Extension Division, the sessions were opened by a welcome and remarks by Paul J. Grogan, Director of Engineering Institutes. The program which followed included:

Monday, December 13

Lighting Maintenance — R. F. VandenBoom, General Electric Co., Milwaukee, Wis.
Industrial Plant Lighting — William B. Kennedy, Sylvania Electric Products, Inc., Milwaukee.
Light Sources: Incandescent, Fluorescent, Mercury; Comparative Costs of Maintenance and Replacement — Carl F. Jensen, Westinghouse Electric Corp., Chicago.
Lighting Design — George Gilleard, Curtis Lighting, Inc., Chicago.

Tuesday, December 14

Economics of School Lighting — J. J. Burke, Wisconsin Power and Light Co., Madison.
Fluorescent Lighting for Street and Area Applications — M. C. Harsh, Line Material Co., Milwaukee.
Outdoor Lighting for Industrial Production and Safety — Howard W. Grosh, Westinghouse Electric Corp., Milwaukee.
Color Conditioning — Brightness Control — L. S. Oyster, E. I. du Pont de Nemours, Chicago.

Speaker for the banquet Monday evening was C. L. Crouch, I.E.S. Technical Director, who discussed lighting in terms of the visual environment.

At the close of the sessions, R. A. Ratner, Assistant Director of Engineering Institutes, presented certificates to those who had completed the course.

ASHVE Announces Adoption of New Name

By a total vote of 4081, a majority of 5919 eligible voting members of the American Society of Heating and Ventilating Engineers expressed their approval of changing the name of the 60-year-old engineering society to American Society of Heating and Air-Conditioning Engineers, Inc. The tellers report showed 3280 in favor, 654 opposed and 147 invalid.

The new name, as decided at a special meeting on Monday, November 22, in the Hotel Statler, New York City, was filed with the Secretary of State of the State of New York and was effective November 23, 1954.

The American Society of Heating and Air-Conditioning Engineers, Inc., is dedicated to carrying on the traditions and enlarging the scope of the worthwhile service visualized by the founding fathers of ASHVE in 1894. President L. N. Hunter, of Johnstown, Pa., emphasized that under its new name the membership will continue to advance the arts and sciences related to heating, air conditioning, ventilating and cooling, and the allied arts and sciences.

Directory Being Compiled Of Industrial Research Laboratories

The National Academy of Sciences—National Research Council is now compiling the tenth edition of "Industrial Research Laboratories of the United States," a directory of American industries and businesses which maintain scientific research and development facilities.

The directory will include nongovernmental laboratories devoted to industrial research. "Research' for the purposes of this directory includes industrial development work on processes and products, as well as fundamental and applied research. Laboratories engaged primarily in routine testing and control but carrying on research activities as well will be listed in the directory.

The directory will indicate the type of ownership or sponsorship of the laboratory (that is, whether it is company-owned, an independent commercial laboratory, a trade association laboratory, or a nonprofit foundation or institute). It will also indicate the kind of research activity performed and the nature of the services offered, such as research only for the parent organization, research on a fee or contract basis, consultation and advice, and testing and analysis.

The number of professionally trained members and technical personnel of the scientific research staff will be shown, as well as the number of additional employees.

Industry purchases a large percentage of each edition; scientific and technical societies use it in their studies; and government agencies often refer to it when awarding contracts for research and development.

Publication is scheduled for mid-1955. There is no charge for listing in the directory. The book is a nonprofit undertaking; the price will be determined by the cost of publication. Industrial laboratories that may wish to be included in the directory but have not received a questionnaire may do so by writing to James F. Mauk, Staff Associate, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.

LIGHTING CALENDAR

Society Events

February 10, 1955—Meeting of I.E.S. Council, New York, N. Y.

March 31 - April 1, 1955 — Southern Regional Conference, Ft. Harrison Hotel, Clearwater, Fla.

April 3-5, 1955 — Southwestern Regional Conference, Gunter Hotel, San Antonio, Texas.

April 11-13, 1955 — Inter Mountain Regional Conference, Westward Ho Hotel, Phoenix, Arizona.

April 14-15, 1955 — South Pacific Coast Regional Conference, Statler Hotel, Los Angeles, Calif.

April 25-26, 1955 — Pacific Northwest Regional Conference, Harrison Hot Springs Hotel, Harrison Lake, B. C.

May 2-3, 1955 — Midwestern Regional Conference, Edgewater Beach Hotel, Chicago, Ill.

May 12-13, 1955 — Canadian Regional Conference, Hotel Mount Royal, Montreal, Que.

May 19-20, 1955 — East Central Regional Conference, Abraham Lincoln Hotel, Reading, Pa.

June 10-11, 1955 — Northeastern Regional Conference, Ft. William Henry Hotel, Lake George, N. Y.

September 12-16, 1955 — Illuminating Engineering Society, National Technical Conference, Hotel Statler, Cleveland, Ohio.

Industry Events

January 7-11, 1955 — National Retail Industry Show, Madison Square Garden, New York, N. Y.

January 31 - February 4, 1955 — American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York, N. Y.

March 13-18, 1955 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

April 17-22, 1955 — Society of Motion Picture and Television Engineers, 77th Semiannual Convention, The Drake Hotel, Chicago, Ill.

May 10-12, 1955 — Chicago Electrical Industry Show, Conrad Hilton Hotel, Chicago, Ill.

May 11-13, 1955 — Pacific Coast Electrical Association, Inc., Annual Convention, Palace Hotel, San Francisco, Calif.

May 12-13, 1955 — Public Utilities Advertising Association, Annual National Convention, Sheraton Hotel, Chicago, Ill.

June 27 - July 1, 1955 — American Institute of Electrical Engineers, Summer General Meeting, New Ocean House, Swampscott, Mass.

July 12-15, 1955 — Western Plant Maintenance and Engineering Show, Pan Pacific Auditorium, Los Angeles, Calif.

August 15-19, 1955 — American Institute of Electrical Engineers, Pacific General Meeting, Butte, Montana.

October 3-7, 1955 — Society of Motion Picture and Television Engineers, 78th Semiannual Convention, Lake Placid Club, Essex County, N. Y.

October 3-7, 1955 — American Institute of Electrical Engineers (Fall General Meeting), Morrison Hotel, Chicago, Ill.

October 5-7, 1955 — Canadian Electrical Manufacturers Association (11th Annual Meeting), Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada.

October 17-21, 1955—National Safety Council, 43rd National Safety Congress & Exposition, Chicago, Ill.

October 24-26, 1955—37th Annual Meeting and Sixth National Conference on Standards, American Standards Association, Washington, D. C.

New England Section, I.E.S., Meets with Electrical Inspectors

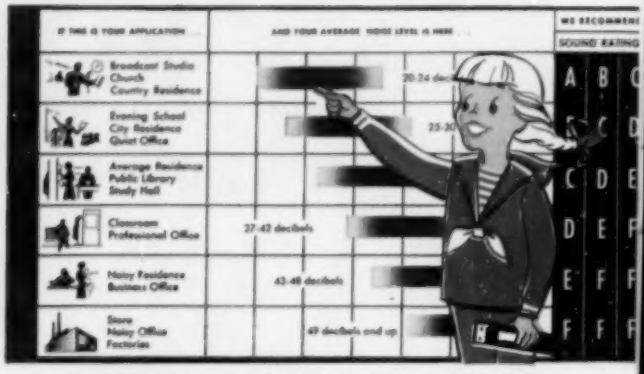
A joint meeting of the New England Section of I.E.S. was held with the Paul Revere Chapter of the International Association of Electrical Inspectors, held November 30 in the Morse Auditorium of the Museum of Science, giving the I.E.S. members a look-in on the affiliated profession. Fred Neumer, associate electrical engineer in charge of the Fixture and Wiring Device Section of the New York office of Underwriters' Laboratories addressed the group on "Why UL Labels on Lighting Fixtures?"

In addition there was a Code Panel discussion by Walter M. Carroll, first vice president, Eastern Section, I.A.E.I. and inspector of wires, Brockton, Mass.; Peter J. Hicks, Jr., public service engi-

(*Continued on page* 11A)

Flora shows you*

General Electric



1. SOUND RATING—Only G-E ballasts are sound-rated to assure you of meeting your sound level requirements. You can choose the proper G-E ballast whether it's for a quiet installation or for an application where noise is less important. G-E sound rating eliminates expensive noise complaints.

4. LAMP-MATCHED DESIGN—The ballast governs light output and life of the fluorescent lamp. G-E ballasts are lamp-matched to provide up to 50% longer lamp life and up to 30% more light output. Here you save two ways—lower lamp replacement costs and more light from your installation.

Whether you use, install, specify or make fluorescent fixtures, G-E ballasts mean savings to you!

The six reasons why you save, described by Flora above, grow out of these simple facts:

- **G-E ballasts are designed to high engineering standards (1, 3, 4, 5 above).**
- **G-E ballasts are made under exacting quality control standards (2 above).**
- **G-E ballasts are backed by complete sales and engineering services (6 above).**

Only G.E. offers you all these money saving features.

In every conceivable way, we make sure you get more when you use G-E ballasts. For example, G-E engineering standards

Copyright 1954, General Electric Company.

Core and coil construction is carefully designed for minimum power loss; close control of noise and heating. Quality insulation throughout—protects against failure, assures longer life.

All components, like this G-E Pyranol† capacitor, are manufactured to our precise specifications.

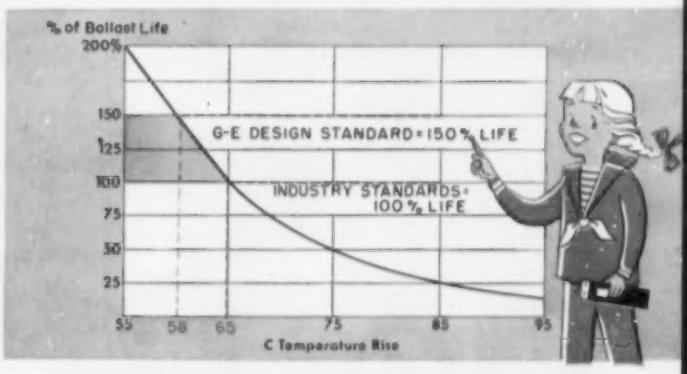
†Reg. trade mark of General Electric Co.

Every part of a G-E ballast is carefully designed, manufactured, tested and assembled to give you the best ballast value.

six ways . . .

ballasts help you save lighting dollars

2. UNIFORMLY HIGH QUALITY—Lighting specifiers have learned to depend upon the consistently high quality of G-E ballasts. Rigid material specifications and constant production line tests mean uniformly good ballasts; save lighting dollars on early replacement and maintenance costs.



3. LONGER LIFE—G-E ballasts are designed to operate 10% cooler than U.L. and Certified Ballast Manufacturers' standards. Tests show that a 10% reduction in ballast temperature rise can mean up to 50% longer ballast life, giving you half again as much ballast life!

5. PROVED PRODUCT LEADERSHIP—General Electric has the largest group of specially trained ballast design and development engineers in the industry. They're constantly improving G-E ballasts, assuring you of all benefits of top quality when you "specify" General Electric.

6. COMPLETE CUSTOMER SERVICES—General Electric's extensive sales, warehousing, and engineering organization is anxious to serve you. These unequalled facilities can provide services for you which no other ballast manufacturer offers. These extra services mean real saving to you.

actually exceed the specifications established by the Certified Ballast Manufacturers where extra quality pays off to you. Another example: Ten quality control stations make dozens of physical and electrical checks during manufacture to assure that each ballast measures up to the high G-E standards.

Next time, specify General Electric Ballasts. Dollar for dollar they're your best ballast value.

LOOK FOR THIS G-E BALLAST TAG →

A G-E ballast tag on your fixture is proof that it's equipped with a top-quality ballast. It's the easy way to be certain. For further information on G-E ballasts, contact your nearest G-E Apparatus Sales Office or G-E Distributor. General Electric Company, Schenectady 5, New York. 463-7

***Miss Flora Ballast, G-E Ballast Mascot.**

Progress Is Our Most Important Product

GENERAL ELECTRIC

Mr. A. L. Kaegel, owner and manager of Kaegel Drug Store in Webster Groves, Mo. Mr. Kaegel recently wrote a letter to Day-Brite. He has kindly given us permission to make his statements public. Mr. Kaegel says:

"I WOULDN'T CHANGE OUR PLEXOLINE LIGHTING IF SOMEONE GAVE ME SOME OTHER FIXTURE."

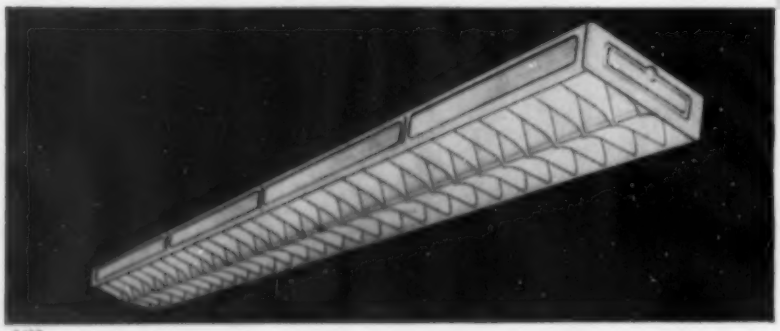
"Those are strong words, I know," continues Mr. Kaegel in his letter, "But I've had experience before with some cheaply made equipment. Now, I've found the best and I'm sticking to it."

"Here's the record," says Mr. Kaegel. "Our PLEXOLINE lighting was installed a year and a half ago. We haven't had one ballast failure in that time, lamps have exceeded their rated life, cleaning and servicing are at least 50% less costly than with any other fixtures we've ever had."

* * *

And may we add one other fact about this well-planned PLEXOLINE store lighting? It was possible because Mr. Kaegel is a smart merchandiser who understands and uses the selling power of good lighting to move goods. Your store lighting can do the same for you. COMPARE PLEXOLINE... *FEEL* THE DIFFERENCE... BEFORE YOU BUY!

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures



5418

DAY-BRITE'S PLEXOLINE®

A complete lighting system especially suited for store lighting. Linear sections, circular accent units. Countless patterns possible including curves, circles and angles. Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis 7, Missouri. In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario.

CALL OR WRITE YOUR NEAREST DAY-BRITE REPRESENTATIVE

(Continued from page 7A)

neers, Providence, R. I.; John W. King, secretary-treasurer, Eastern Section, I.A.E.I.; and Bernard B. Whelan, superintendent of electrical inspection, Boston.

An I.E.S. guest from out of the Section was C. W. McCormick, Vice-President of the Society's Northeastern Region.

Southern California Section Sees Lighting for Color TV

Record-smashing attendance was achieved at the November 3 meeting of the Southern California Section, when the meeting featured a demonstration of lighting for color television at CBS Television City, Los Angeles. A total of 349 members and guests heard Mr. Gus Peterson, Lighting Superintendent at CBS, show how the art of illumination is applied to color TV, demonstrating such equipment as the Izenour control board, the patch panel, thyratron dimmer controls, and batten lighting. Other speakers were Victor Larkin, Manager of Construction and Building Operation for CBS, and Joe Cohen, Supervisor of Television Maintenance.

During a question and answer period, the camera operator directed his machine at the questioner, who was then able to watch himself on the screens of two color and two black and white receiving sets or monitors.

EEI Sums Up Electric Industry in 1954

The year 1954 was notable in the electric industry according to a report by the Edison Electric Institute. The Diamond Jubilee year of the electric light, it marked 75 years of amazing growth and change since Thomas A. Edison's great discovery. The industry's 50 millionth customer was added in January. The five millionth farm was connected for electric service a few weeks later. On the very anniversary day of the incandescent lamp, October 21, the country's 100 millionth kilowatt of generating capacity was put into operation at the St. Clair, Mich., plant of the Detroit Edison Co.

More new generating capacity was added than ever in the country's history —11.5 million kilowatts of capability, well above the previous high of 10.1 million kilowatts of 1953.

Electricity in the Home. Average consumption of electricity increased by 194 kwhr per domestic customer, the largest annual gain on record.* Total average use by the householder was 2540 kwhr for the year. Sales to domestic customers alone were greater than the total sales to all classes of customers only fifteen years ago. Use of electricity by domestic customers now accounts for 26.4 per cent of all electricity sales.

Farm Service. By the end of 1954, an estimated 5,090,000 farms had electric service, 94.6 per cent of the over-all farm figure. All but 2 per cent of the nation's occupied farms now either have electric service or have it readily available.

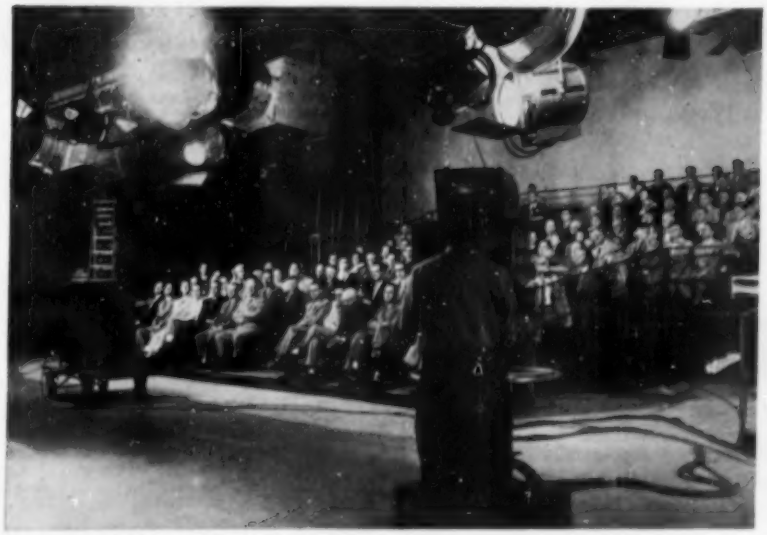
Atomic Power Developments. Ground was broken, September 6, at Shippingport, Pa., for the nation's first full-scale power plant which will use atomic fuel. Duquesne Light Co. will finance and build the generating portion of the plant, Westinghouse Electric Corp. will build the nuclear reactor, under contract with the Atomic Energy Commission, and Duquesne Light will operate the entire plant.

Many groups of power companies in different sections of the country, including the Pacific Northwest, are actively studying atomic power developments with a view to proceeding with such undertakings as fast as circumstances warrant.

Gains in Operating Efficiencies. Continuing gains in operating efficiencies of electric companies were demonstrated during the year. As one example: out of the same size coal pile used by the electric industry last year, the industry produced 28 billion more kilowatthours than in 1953, an 8.2 per cent gain. This amount gained from efficiency improvement is equal to more than half the total kwhr production thirty years ago. Generating units on the average have doubled in capacity over prewar installa-

(Continued on page 12A)

OFFICIAL certificate of Fellow grade in the I.E.S. was presented to Miss Myrtle Fahsbender at a recent meeting of the Residence Lighting Forum of the New York Section. Presenting the certificate is Lou Goren, Vice-Chairman of the New York Section.



DEMONSTRATION of lighting for color television drew the record attendance of 349 at the Southern California Section's November 3 meeting at CBS Television City, Los Angeles. Photograph shows some of the members and guests. On wheels at left is a color receiving set or monitor, two of which were used, as well as two black and white.

(Continued from page 11A)

tions. This has been an important factor in keeping down unit costs.

Forecast for the Future. The industry's Diamond Jubilee year also produced an extensive survey and forecast for the future which indicates that by the year 1965 demand for electric power will be double that of today, and that by 1975 a three- or even four-fold increase in the use of electric energy by the homes, farms, stores and factories of the nation is expected.

Architect-Engineer Panel Discussion Makes Successful Michigan Meeting

Discussion by a panel of architects and electrical engineers on the subject of modern illumination from both viewpoints made a stimulating program for the second meeting of the Michigan Section, November 9, in the auditorium of the Detroit Edison Co. Purpose of the panel discussion was to create greater understanding, cooperation and unity of purpose between the two groups.

Panel members were:

Linn Smith, architect, President of the Michigan Society of Architects.

Leroy E. Kiefer, architect, Director of Product and Exhibit Design, General Motors Styling Section.

Robert N. Scott, electrical engineer, member of Smith-Hinchman and Grylls Inc.

Mister Lighting Critic, anonymous.

DURING discussion from the floor, following the Michigan Section architect-engineer panel session, are: left to right: Floyd Sell, Chairman, Michigan Section; Linn Smith, architect panel member; Lee Tayler, alias Mr. Lighting Critic; Robert N. Scott, engineer panel member; Leroy E. Kiefer, architect panel member; and Jack Parks, Program Chairman.

The anonymous Mister Lighting Critic made many timely, off-stage comments, even "heckling" a bit. (He later proved to be Lee Tayler, of Detroit Edison.)

Slides of outstanding lighting jobs were shown and comments made by the panel, following which there was spirited discussion from the floor.

I.E.S. Regional Conferences — 1955

Southern	Fort Harrison Hotel Clearwater, Florida	March 31-April 1
Southwestern	Gunter Hotel San Antonio, Texas	April 3-5
Inter-Mountain	Westward Ho Hotel Phoenix, Arizona	April 11-13
South Pacific Coast	Statler Hotel Los Angeles, California	April 14-15
Pacific Northwest	Harrison Hot Springs Hotel Harrison Lake, British Columbia	April 25-27
Midwestern	Edgewater Beach Hotel Chicago, Illinois	May 2-3
Canadian	Mount Royal Hotel Montreal, Quebec	May 12-13
East Central	Abraham Lincoln Hotel Reading, Pennsylvania	May 19-20
Northeastern	Fort William Henry Hotel Lake George, New York	June 10-11

Advance Program Announced For Street Tree & Utility Conference

The tentative program, with still a few speakers to be announced, has been released for the Street Tree and Utility Conference, to be held at Wade Park Manor in Cleveland, on March 3-4, 1955.

The two-day meeting will be held in four sessions — Why, Design, Examples of Coordination, and a Forum.

On the first day, the morning session will be on:

Why

Our Streets Can Be Beautiful — And Useful —speaker to be announced.

1954 Hurricanes Pin-Point the Need for Long-Range Coordinated Programs—speaker to be announced.

Why Street Trees? — Charles Young, City Forester, Baltimore, Md.

Why Street Lighting? — D. M. Baldwin, National Safety Council, Chicago, Ill.

Why Overhead Lines on Public Streets? — G. E. Dean, Public Service Electric and Gas Co., Newark, N. J.

The afternoon session will be concerned with:

Design

Design of Street Lighting — Standards and Permissible Departures — W. H. Edman, Holophane Co., Newark, Ohio, and H. W. Osborne, City of Buffalo, N. Y.

Power Line Design for Compatibility with Trees — E. V. Sayles, Consumers Power Co., Jackson, Mich.

Coordination of Telephone Lines with Street Trees — Forrest Woodland, American Telephone and Telegraph Co., New York, N. Y.

Sub-Surface Problems of Trees and Utility Structures — S. S. Baxter, City of Philadelphia, Pa.

At the dinner on the evening of March 3, E. H. Scanlon, Consulting Arborist and Editor of *Trees*, will speak on the "Selection and Use of Trees to Minimize

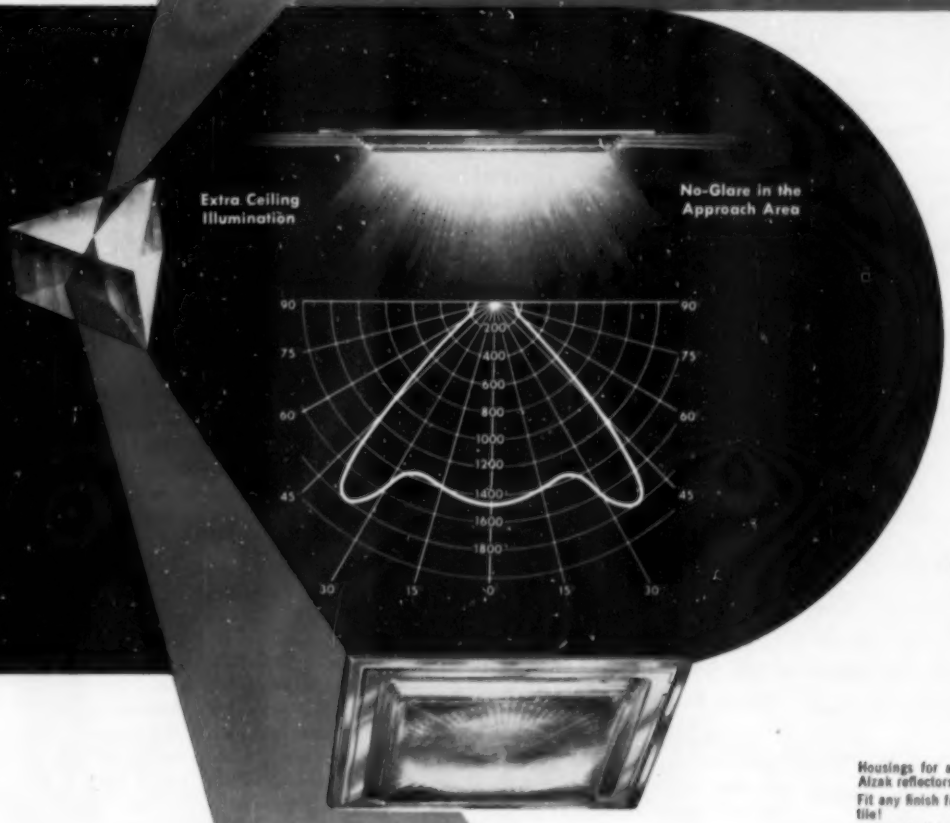
(Continued on page 14A)

STRATO-RAY lens

SOMETHING NEW IN LIGHT CONTROL

Pry-Lite

recessed lighting fixtures for commercial installations



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- **SIX MODELS**

vertical lamps
horizontal lamps
150—300 watts

- **THREE TYPES**

SHALLOW
prewired—2100 series
STANDARD
pre-wired—2200 series
CEMENT FIXTURE
not pre-wired—2300 series

Housings for all types are sturdy, galvanized steel with Alzak reflectors.

Fit any finish from ½" to 2"—Replaces one 12" acoustical tile!

Choice of attractive chrome or baked enamel finish—Asymmetrical lens for corridor—Wide angle lens for general illumination—Tamper-proof or Trip-Latch hinged frames.

SPECIFY THE LINE DESIGNED BY

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rhymes with FINE...and means it!

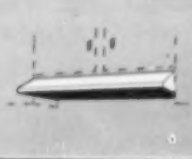
BOX IE-15, POMONA, CALIFORNIA

Eastern Factory: Keyser, West Virginia
Canadian Factory: Toronto, Ontario
Warehouses: Los Angeles; San Francisco; Chicago; Newark, New Jersey
Distributed by Electrical Wholesalers Everywhere in the U. S. and Canada

AEROFAN
Ceiling and sidewall exhaust fans.

BLO-FAN
America's most imitated electric exhaust ventilator.

GLOMASTER
Heats your home like the sun heats the earth.



PRYNE TILTING-HOOD
It's a Blo-Fan
It's a Pry-Lite
It's a New Idea.

CONFERENCE Committee Chairmen for the South Pacific Coast Regional Conference, to be held April 13-15 in Los Angeles, meet to make plans. Left to right are: seated, Merle Potter, Vice-Chairman of the Conference; Mrs. Roy Kreyser, Ladies; Jack Rohring, Conference Chairman; Wm. P. "Teddy" Bear, Registration; Hugh Sheeter, Hotels; standing, Roy Jones, Papers and Program; Jack Russell, Attendance; G. A. Hochenauer, Finance; Lloyd Reuscher, Entertainment; Del Reynolds, Publicity. Other Committee Chairmen, not shown in photo are: William Shalda, Budget; Charles Connely, Space and Properties; and Benn Hartmann, Transportation.

(Continued from page 12A)

Public Area Conflicts." Kirk M. Reid, General Electric Co., will preside.

Mr. Scanlon will act as Chairman of the March 4 session, which will begin with:

Examples of Coordination

Street Lighting
- R. E. Dahlin, Southern California Edison Co., Los Angeles, Calif.
- F. J. Schmitt, Rochester Gas & Electric Co., Rochester, N. Y.
- J. W. Young, New England Power Service Co., Boston, Mass.
- D. A. Toenjes, General Electric Co., Cleveland, Ohio.

Overhead Lines
- R. Hickock, Connecticut Light and Power Co., Hartford, Conn.

and two other contributors to be announced.

Street Trees
- G. D. Blair, Forestry Consulting Services, Jackson, Mich.
- W. I. Myers, Superintendent of Forestry, City of Detroit, Mich.
- J. A. Sweeney, City Forester, Toledo, Ohio.
- J. A. Dietrich, Superintendent of Trees, Greenwich, Conn.

The closing session on the afternoon of March 4 will be a panel of all the speakers, with questions and discussions from the floor. Professor H. O. Perkins, University of Connecticut, will give the "Conference Summary — and the Next Steps."

Co-Chairmen of the Conference are Kirk M. Reid, of I.E.S., E. H. Scanlon, of the National Shade Tree Conference, and J. W. Anderson, of the Edison Electric Institute.

The registration fee of $12.50 includes the banquet and a copy of the Conference Proceedings in which all papers and discussions will be printed. Registration, with fee, should be sent to E. H. Scanlon, 7621 Lewis Road, Olmstead Falls, Ohio. Hotel reservations should be made directly with Wade Park Manor mentioning attendance at the Street Tree and Utility Conference.

ASEE Schedules Annual Meeting in June

The American Society for Engineering Education has scheduled its annual meeting for June 20-24, 1955 at Pennsylvania State College, State College, Pa. This meeting is attended each year by more than 2,000 educators and educational administrators from engineering colleges throughout the country. A welcome is being extended this year also to guests from foreign nations, with a program on the international aspects of engineering education included.

At one of the general sessions, the program will feature reports of two of the society's committees. One, the Committee on Evaluation of Engineering Education, will make its final report on its study of the objectives and curricular goals of engineering education, with particular emphasis on the changes which are needed to keep abreast of the advancing frontiers of science and technology. Another committee report will deal with the teaching of the humanities, social sciences and business studies in the engineering curriculum. This committee is endeavoring to seek out those educational programs which show fresh and imaginative approaches with promise of making exceptional contributions in terms of educational achievement.

The Engineering College Research Council will have a general session dealing with Education for Research; and the Engineering College Administrative Council will feature one on methods of Interesting Secondary School Students in Engineering as a Career.

More than 75 conferences are scheduled, dealing with all areas of engineering education, physics, mathematics, international relations, research, and others bearing upon the broad subject of engineering education.

Printed programs for the meeting will be available about the end of April. For further information, write to the Secretary of ASEE, Northwestern University, Evanston, Ill.

Many Prizes Offered In EEI Contests

Nine prize award contests, offering to operating light and power companies or their employees 31 awards for various outstanding accomplishments during 1954, have been announced by the Edison Electric Institute Prize Awards Committee.

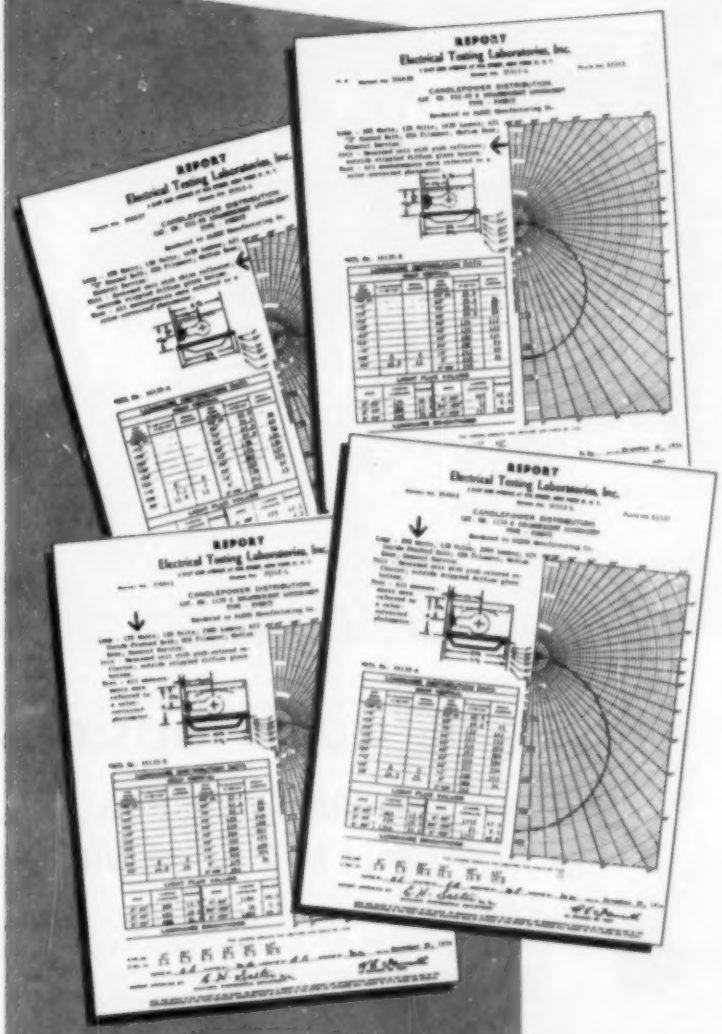
In the field of commercial activities, there are seven contests with 11 different classes and 25 awards. Electric range, electric water heater and commercial cooking activities are covered by the George A. Hughes Awards. The Laura McCall Awards are for outstanding home service achievements; this year there has been a simplification which will favor small and medium sized companies. Planned Lighting Awards are for three types of promotion: industrial, commercial and residential lighting. The George Westinghouse Awards cover outstanding performances in the promotion of electric laundry equipment. General Electric's More Power to America Awards are for achievements in broad-scale industrial electrification. The Frank Watts and Thomas W. Martin Awards cover rural electrification accomplishments.

Other awards are the Reddy Kilowatt Annual Report Award for excellence in annual reports, and the Claude L. Matthews Award for valor.

"It is important to remember that the major determinant of winners of these awards is a company's accomplishment in relation to the area it serves and the

(Continued on page 17A)

HAP-E-LITE a new concept in lighting



PHOTOMETRIC REPORTS ON HAP-E-LITE AND OTHER ALKCO FIXTURES ARE AVAILABLE ON REQUEST

HAP-E-LITE TRADE MARK

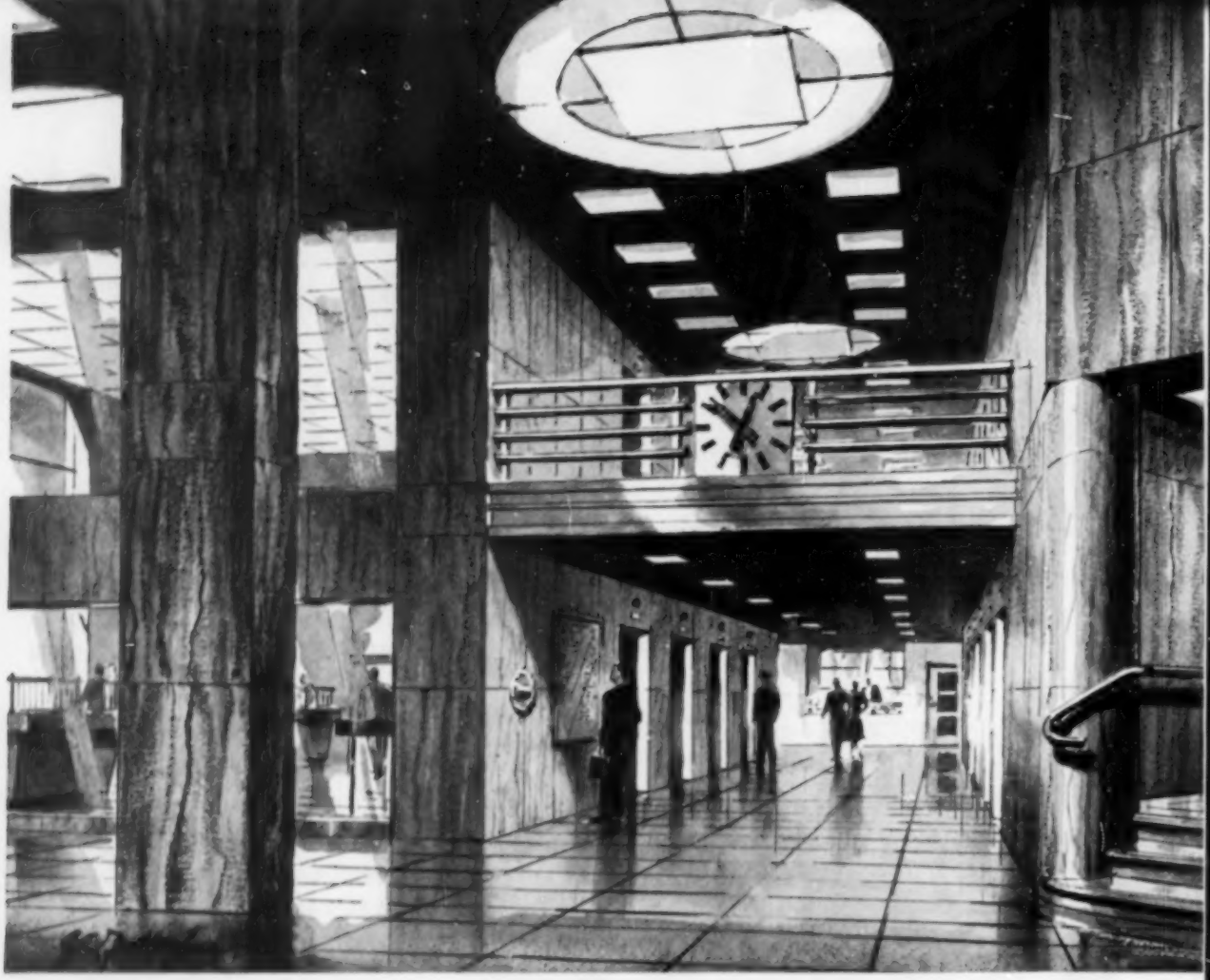
DEVELOPED by ALKCO AFTER YEARS of RESEARCH

Hap-E-Lite achieves soft, warm tones by a patented blending process using standard incandescent lamps. This new concept in lighting compliments the complexion and adds warmth of color to the surroundings. The superiority of Hap-E-Lite over ordinary incandescent light can be readily seen in comparison tests.

Hap-E-Lite is now available in all recessed and surface-mounted incandescent fixtures in the new 1955 Alkco line.

Write today for ALKCO's New — COMPLETE 1955 CATALOG and PRICE LIST

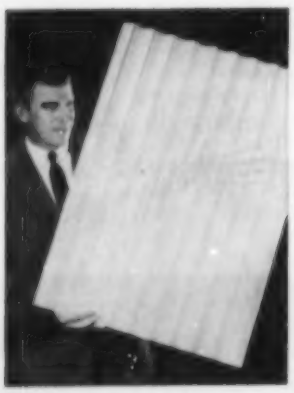
ALKCO MANUFACTURING CO. 4242 LINCOLN AVE. CHICAGO, ILL.



Lightweight, rigid 4' x 4' modular unit of extruded "Lucite." This unit evenly diffuses and transmits pleasing light without glare—it also withstands direct exposure to sunlight.

Good lighting is good business

Utilize the superior lighting properties of Du Pont LUCITE® acrylic resin



Beautiful effects and light-diffusing ceilings are also made from corrugated panels of extruded "Lucite." This versatile material offers strength, rigidity and durability with freedom from discoloration.

Leading architects and lighting engineers know the importance of lighting as a modern design element. Du Pont "Lucite" gives a harmonious architectural blending of design and light at efficient levels. Extruded "Lucite" pleasingly diffuses and faithfully transmits light at low surface brightness. It has exceptional strength, durability and freedom from discoloration . . . assures years of steady peak lighting performance.

"Lucite" can be found to meet a wide variety of design specifications. It is readily fabricated in modular-size units and corrugated panels which are used in luminous ceilings or islands of light to create beautiful effects. "Lucite" is available in many colors.

Write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 281, Du Pont Building, Wilmington 98, Delaware, for further information on extruded "Lucite."

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

(Continued from page 14A)

conditions it has to meet in that area," according to Harry Restofski, Chairman of the Prize Awards Committee and Vice-President, West Penn Power Co. "Therefore, a company with 30,000 meters stands just as much chance of winning as a company with 300,000 meters."

Deadline for entries in the seven commercial contests and for the Matthews Award are February 1 and 15, 1955. Deadline for the Annual Report Award is May 14, 1955. Further information on any of these awards may be obtained from the Edison Electric Institute, 420 Lexington Avenue, New York 17, N. Y.

NEMA, Utilities, and REA Encourage Rural Electrification

The National Electrical Manufacturers Association, which held its annual meeting in Atlantic City, November 10, has given approval to its Farm and Rural Market Development Committee to participate in a joint activity with utility companies and REA Cooperatives, aimed at increasing the electrical load in the nation's rural areas.

Announcement of approval by the Association's Board of Governors was made at the meeting of the Committee's Load Development Subcommittee, which is responsible for NEMA's part of the new rural program. This activity will bring together for the first time, commercial power companies, REA financed cooperatives and electrical manufacturers in a concerted effort to encourage the greater purchase and use of both household appliances and electrically operated farm production equipment. The program is spearheaded by the Inter-Industry Farm Electric Utilization Council, which is composed of representatives from the three interested organizations. NEMA's representatives are W. E. Saylor, Kelvinator Division, American Motors Corp., Detroit, and W. D. Hemker, Agricultural Engineer, Westinghouse Electric Corp., Pittsburgh.

Bibliography on Lighting Available from Headquarters Office

A list of books, publications and periodicals, compiled and kept up-to-date by the I.E.S. Committee on Lighting Education, is available from the Technical Department at I.E.S. headquarters office. Consisting of nine mimeographed sheets, this bibliography on light and lighting covers publications which make a definite contribution to the field of illumination, grouped according to the subject matter which they represent.

These sections are (1) Lamps and Lighting, (2) Architecture and Lighting, (3) Physics of Light—Optics, (4) Color, (5) Light, Eyesight and Health—Related Psycho-Physiological References, (6) Trade Papers and Professional Journals in both English and foreign languages.

How Some Germs Recover From UV Radiation

How do some germs and other microorganisms, supposedly destroyed by a fatal dose of ultraviolet radiation from germicidal lamps, manage to survive the lethal rays and revive when bathed again in visible light?

This mystery, first reported by Dr. Albert Kelner of Brandeis University, has been under investigation by Dr. W. D. Bellamy and Miss M. T. Germain of General Electric Research Laboratory, as important from a public health standpoint.

Dr. Kelner had suggested that it might be due to the fact that some microorganisms possess "cytochrome systems," tiny iron-containing cell pigments that are able to use oxygen to change sugars, proteins and other food substances into "body-building" materials.

This suggestion was confirmed by Dr. Bellamy, before the eastern New York branch of the Society of American Bacteriologists in Albany on November 18, when he presented clear evidence that among microorganisms studied, only those possessing systems with the all-important traces of iron-containing pigments were able to be revived.

Since revival depends upon administering visible light radiation, the term "photo-reactive" is applied to those microorganisms able to exhibit rejuvenation. Dr. Bellamy and Miss Germain worked with four species. Two contained cytochrome systems and became photo-reactive after being supposedly "dead." The other two, which were without the metallic pigments, failed to respond.

Still to be tested are further theories that the action of ultraviolet light either (1) destroys the ability of bacteria to produce food and thus makes some bacteria starve to death, or (2) produces a poison within the bacteria that disappears in certain species upon exposure to visible light.

It Seems to Run In Some Families

The Inter-Mountain Region of I.E.S. seems to have a tendency to twin events, as pointed out by Regional Vice-President G. B. Buck II. Back in June 1952, a Flying Delegation from the parent Rocky Mountain Section visited in one day the charter ceremonies of the twin Southern Colorado Chapter and New Mexico Chapter.

(Continued on page 18A)

SIGNING of the proclamation of "Electrical Week" in Massachusetts October 18-24 by Governor Christian A. Herter is attended by, left to right: B. D. Gross, president, Massachusetts Electrical Contractors Association; Joseph Ross, president, Paul Revere Chapter, International Association of Electrical Inspectors; Norman Richardson, president, Greater Boston Chapter, National Electrical Contractors Association; C. A. Stone, editor and publisher, *New England Electrical News;* B. B. Whalen, superintendent of wires, Boston; and E. J. Perkins, Chairman, New England Section, I.E.S.

(Continued from page 17A)

Now, through a constitutional process unknown to medical history, the Utah Chapter and the Arizona Chapter have also become twins — simultaneously achieving the maturity of Section status.

Ceremonies Mark Awarding of First Lighting Certification

The first Certification, under the industrial and commercial relighting promotion program of the National Lighting Bureau, was awarded December 22, 1954, to the Fall River, Mass., Police Station. During appropriate ceremonies, attended by municipal and electric lighting industry leaders, the Number 1 Certificate of Conformance to Illumination Standards was conferred upon officials of the Fall River Police Department.

Fall River, Mass., is within the area of the Certified Lighting Bureau, Electrical League of Rhode Island.

Power Suppliers Meet On 4-H Electric Program

More than 100 electric utility and electric cooperative representatives were present at the Fourth Annual Power Supplier Conference on the 4-H Electric Program at the Conrad Hilton Hotel, Chicago, December 1. Designed to help power suppliers exchange ideas and develop new methods of working with the 4-H Electric Program, this Conference coincided with the 33rd national 4-H Club Congress.

The 4-H Electric Program is an extension service project sponsored for the past 19 years by the Westinghouse Educational Foundation in cooperation with the U. S. Department of Agriculture and the State Extension Services, and is affiliated with the national 4-H Club Congress. One of the objectives of the Program is to encourage 4-H Club members to learn more about electricity and to use and care for electrical equipment. At the Power Supplier Conference, H. P. Sedwick, President of the Public Service Co. Division of Commonwealth Edison Co., spoke on the important role rural youth can play in farm and home electrification.

Safety Council Announces New Industrial Safety Material

The National Safety Council has announced the availability of several new booklets and films on safety in industry.

Two 12-minute films, prepared under the direction of the Council's industrial department are "Take Time to Live," and "If You Took Your Family to Work." These are available in 16mm sound movies and 35mm sound slidefilms.

"Accident Rates," 1954 series, contain the 1953 accident experience of all companies that report to the Council, in separate booklets for each of fifteen industries or groups of industries. Each volume provides the current accident rates for the industries involved and a historical rundown of rates for some years back. A bar chart shows the standing of 40 industrial classifications.

The 1954 edition of "Accident Facts," the Council's statistical yearbook, is also now available. The 96-page book contains facts and figures on all types of accidents — industrial, traffic, home, farm and school. A large section of the book is devoted to occupational accidents and provides factual background on industrial safety programs.

Information on prices and availability of this new safety material may be obtained from the National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.

Optometrists Shown Benefits Of I.E.S. Participation

The benefits to optometrists of participation in I.E.S. activities and in membership in the Society were outlined in the October 1 issue of *Barstow's Bulletin for Optometrists*. The newsletters stresses the mutual advantage of contact between the two groups—engineers and optometrists.

Trade Associations Cited for Small Business Safety Promotion

Eleven trade associations were presented with the National Safety Council's award for outstanding work in promoting safety in small business. The awards were made during the sessions of the 42nd National Safety Congress in Chicago, October 18-22, by E. C. McFadden, Council vice-president for industry, and vice-president of the Texas Employers Insurance Association. Presentation was made at a special luncheon meeting for association executives, on October 19 to:

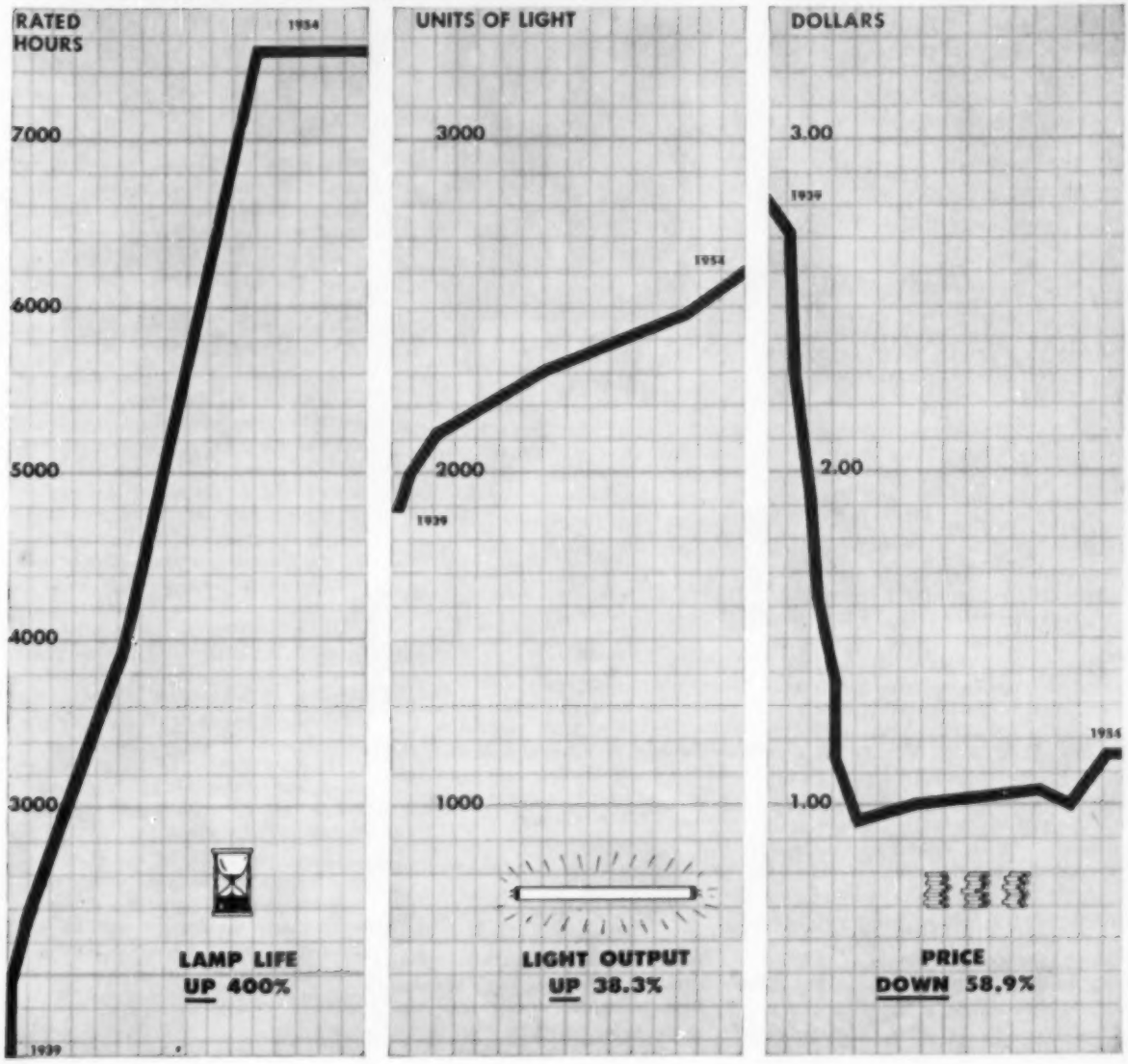
Associated General Contractors of America
British Columbia Loggers Association
British Columbia Lumber Manufacturers Association
Can Manufacturers Institute
Folding Paper Box Association of America
Industrial Accident Prevention Associations (Canada)
Manufacturing Chemists' Association
New York Shipping Association
Portland Cement Association
Society of Exploration Geophysicists
Steel Founders' Society of America

The award gives recognition to associations for the general excellence of their safety services and for their contributions to the reduction of occupational injuries in their industries. The Council's

(Continued on page 20A)

HISTORICAL display of street lighting lamps and equipment used in Victoria, B. C. from 1885 to the present day evoked keen public interest, as part of the Light's Diamond Jubilee celebration of the British Columbia Electric office building. The display ranged from the early Adams Arc Lamp to the modern mercury and sodium lamps.

YOU EXPECT THE BEST VALUE FROM G-E FLUORESCENT LAMPS



16 times more value for your fluorescent lamp dollar than in 1939

Today you don't have to pay more than $1.15 for the finest fluorescent lamp made: General Electric. Sixteen years ago it would have cost you $2.80 or $1.65 more. And while price has been going down, we've been pushing quality up. General Electric has upped light output 38%, increased lamp life 400%.

In terms of what you really judge lamps by, a General Electric 40-watt fluorescent lamp that lists at $1.15 today is a *16-times bigger value than it was in 1939.*

For further information, contact your G-E lamp supplier or write to Lamp Division, General Electric, Department 106-IL-1, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

(Continued from page 18A)

technical committee and committee of judges took into consideration accident prevention activities such as publicity, safety conferences, contests and publication of technical material.

S. G. Hibben Retires Past President of I.E.S.

Samuel G. Hibben, former director of applied lighting for the lamp division of Westinghouse Electric Corporation, and a past president of the Illuminating Engineering Society, has retired after nearly 40 years of service to the lighting industry.

An internationally known authority on illumination, Mr. Hibben has devoted his career to practical applications, of public benefit, of the latest techniques in lamps and lighting.

Born in Hillsboro, Ohio, Mr. Hibben was graduated from the Case Institute of Technology in Cleveland with a bachelor of science degree in 1910. In 1914, Case awarded him the degree of electrical engineer for his study of light-controlling glassware, and he later took post-graduate work at the Carnegie Institute of Technology, Pittsburgh, Pa., and at the University of Paris, France. In 1952 Case Institute awarded him the honorary degree of Doctor of Engineering.

Mr. Hibben's first job was with Macbeth-Evans Glass Company, Pittsburgh, from 1910 to 1914 where he designed lighting glassware and broadened his experience in the illumination field. From 1913 to 1915 he worked in Pittsburgh as a consulting engineer, most of his work involving the design and testing of searchlights for European governments. In 1915 he joined Westinghouse as a meter design engineer at the East Pittsburgh works and later became a lamp engineer at sales headquarters, where his service was interrupted by World War I.

He rejoined the company in 1919 as a supervisor in the Cleveland division office, but was soon called to Bloomfield, N. J., to develop a lighting service bureau which was the forerunner of the Westinghouse lamp division's present commercial engineering department. In 1933 he was named director of applied lighting.

In his active professional career Mr. Hibben has been associated with many "firsts." His early work included design for mobile anti-aircraft searchlights (1917); a design for lighthouse lenses of American manufacture (1920); design of acceptable semi-indirect lighting fixtures, and he was a member of a

S. G. Hibben

group of scientists that developed the initial "cluster" street lights. He directed the designing of a system of transcontinental airway beacons in 1927, and also the first modern floodlighting for public monuments and for airports in 1928.

He worked also with early lighting designs for underwater rescue work and photography, collaborating with noted scientists in submarine photography and studies of ocean life in Bermuda and Atlantic waters. This is a natural outgrowth of Mr. Hibben's earlier pioneer work in the broad field of marine illumination which, in 1928, resulted in the development of lighting equipment for swimming-pool lighting, and such specialized equipment as lamps for deep-sea divers and submarines.

He was one of the pioneers in the application of radiation to plant growth and insect control (1924); the use of "black light" to discover flaws in materials, to develop fluorescent lighting, to discover previous ores, to aid dentists in spotting infected teeth, and to detect the presence of ringworms (1929); and in the use of ultraviolet rays to kill bacteria in schools, hospitals and public gathering places (1930).

He is an authority on the floodlighting of public sites and monuments, and his designs light the Statue of Liberty, the Washington Monument, Natural Bridge (Va.), Holland Tunnel (1927), Carlsbad Caverns, Endless Caverns (Va.), and Crystal Caves, Bermuda (1937).

Mr. Hibben was a member of the Lighting Committee in Charge of Designs and Motifs for the Philadelphia Sesquicentennial (1926) and the Barcelona Exposition (1929). He was responsible also for a substantial part of the lighting at the Century of Progress Exposition, Chicago, where he introduced mercury-vapor lighting (1933), and the New York's World's Fair (1939).

Mr. Hibben served the nation in both World War I and II. In World War I he was an officer with an Army searchlight and sound-ranging battalion in France, attaining the rank of captain. Following that war he traveled through France with a commission estimating the damage to public and industrial property.

In World War II he served in the Office of Civilian Defense, recognized as an authority on defense lighting, blackouts and underwater lighting with the use of many unusual lamps.

In 1945, this time as a colonel, he again was a member of a group of American experts assigned by the Army to survey and appraise strategic bombing results in Europe.

In 1951-1952, Mr. Hibben served as president of the Illuminating Engineering Society, of which he is a Fellow, and was the I.E.S. national secretary in 1922-1923, and its treasurer in 1943-1944, as well as member or chairman of numerous committees. He was an engineering delegate from the United States to the Congress of the International Commission on Illumination in Paris in 1948 and in Stockholm in 1951.

He is a member of many professional societies, including the American Institute of Electrical Engineers, the British Illuminating Engineering Society and the Ohio Society of New York, and is a past-president of the Montclair Society of Engineers. He is also a member of the Engineers Club of New York and a Fellow of the Distinguished Service Foundation of Optometry.

As lecturer, author of numerous technical papers, and recipient of the Westinghouse Order of Merit, Mr. Hibben is truly a versatile scientist with an outstanding record of accomplishments.

He and Mrs. Hibben will continue to make their home in Montclair, N. J.

IT SEEMS TO ME

Why Quartz Shatters At 600C

In reading the article by C. E. Weitz on "Characteristics of Fused Quartz," November 1954 ILLUMINATING ENGINEERING, I note on page 514 what may or may not be a misleading statement, depending on how it is interpreted.

In the paragraph where Mr. Weitz says "crystal quartz can't be used for lamps and many other applications," he states correctly that quartz crystals change and may shatter at temperatures around 600°C. His next statement, "it seems that even in compacted crystal particles there is bound to be as much as

(Continued on page 23A)

WAKEFIELD PRESENTS Wākon

an advanced formulation of rigid polyvinyl chloride created especially for the Wakefield Ceiling diffuser

The Wakefield Ceiling now becomes available with a Wākon diffuser as well as with the original acrylic diffuser. Formulated especially for the Wakefield Ceiling, Wākon has a low flame spread rating and superior ultra-violet resistance. It does not hinder sprinkler distribution, and possesses the air diffusion characteristics of the multi-function Wakefield Ceiling. It also has excellent diffusion and transmission properties. And finally it combines low cost with ease of cutting on the job. Write for detailed information on Wākon to

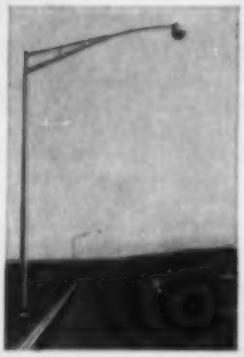
THE F. W. WAKEFIELD BRASS COMPANY, VERMILION, OHIO
In Canada: **WAKEFIELD LIGHTING LIMITED, LONDON, ONTARIO**

Wākon has been tested by Wakefield engineers for

- **RIGIDITY**
- **LIGHT DIFFUSION**
- **FLAME SPREAD RATE**
- **ULTRA-VIOLET RESISTANCE**
- **LIGHT TRANSMISSION**

P&K

PIONEER *producer of the*
MODERN LOW-COST-LIGHTING
STANDARD AND BRACKET



P & K specialization, engineering and plant facilities have for years been devoted to the problem of how to achieve better lighting at lower cost for streets and highways . . . for parking and recreational areas . . . for traffic signals . . . for shopping centers.

WHEN YOU SEE:

- The seamless, tapered, high strength aluminum shaft . . .
- The patented, seamless elliptical all-aluminum arm . . .
- The strong, non-deteriorating "Aircomatic" weld . . .
- The clean, modern scroll-less bracket design . . .
- The smooth-surfaced, strong grain transformer shoe and pedestal bases . . .
- The numerous shaft diameters and arm mounting heights . . .

YOU KNOW:

This is a P & K contribution to modern lighting at far lower cost. You know, too, that P & K costs *less to buy, less to install, and costs practically nothing to maintain!*

WRITE FOR THE LATEST P & K CATALOG . . . and use the planning and advisory services without obligation.

Pfaff & Kendall

84 Foundry Street
Newark 5, New Jersey

(Continued from page 20A)

30 per cent of air or void space," is probably true but it is not the reason that quartz shatters at temperatures around 600°C. The reason for it, as is known to almost every glass technologist around the country, is simply that crystal inversion occurs in natural quartz crystals at 575°C, from the alpha to the beta form of quartz, with a large change in the volume of the crystals.

While this may be a very small criticism of an excellent article, I do believe that technical accuracy is important in such descriptions. H. F. KINGSBURY, *Product Development Engineer, Pittsburgh Corning Corp., Port Allegany, Penna.*

I.E.S. National Technical Conferences

1955 — September 12-16 — Cleveland, Ohio

1956 — September 17-21 — Boston, Massachusetts

1957 — Date to be set — Atlanta, Georgia

1958 — Date to be set — Toronto, Ontario

ABOUT PEOPLE

Election of four engineers to the grade of Fellow in the American Institute of Electrical Engineers was announced by N. S. Hibshman, Institute Secretary. The new Fellows are: **Dr. Orestes H. Caldwell**, editor and science writer; **Dr. Lewis M. Hull**, chairman of the board, Aircraft Radio Corp.; **Anthony J. Pansini**, manager, Meters and Distribution Department, Long Island Lighting Co.; and **Walter S. Gordon**, consulting engineer.

The Holden Line Co., Cleveland, Ohio, has passed to new ownership and management. New president of the firm is **E. M. Smith**, president and sales manager of the Canton Manufacturing Co., Canton, Ohio, makers of load binders for trucks, trailers and railroad cars. Executive vice-president and treasurer is **Earl R. Earnest**, executive vice-president of the Tyson Roller Bearing Co. and the Domar Co. of Massillon, and of the Heston & Anderson Division, St. Paul Foundry and Manufacturing Co. Other directors will be **Herman L. Vail**, Cleveland attorney, who will also serve as secretary; **C. W. Close, Jr.**, president of American Forge & Manufacturing Co., Pittsburgh; and **G. M. Cook**, Cleveland accountant. The new management plans to manufacture and market a complete line of commercial and industrial fluorescent equipment.

George E. Herrmann has been named office manager of the American Institute of Electrical Engineering, succeeding **Floyd A. Norris**, who has retired after half a century of service. Mr. Herrmann was formerly chief accountant and assistant office manager of the American Institute of Mining and Metallurgical Engineers.

Miss Eve Freyer has joined the Residential Lighting Department of Westinghouse Lamp Division, it was announced by Myrtle Fahsbender, director. A graduate of Cornell University with a bachelor's degree in electrical engineering, Miss Freyer comes to Westinghouse from the headquarters staff of the Illuminating Engineering Society, where she was engineering assistant to the technical director. In her new position Miss Freyer will assist Miss Fahsbender in her nation-wide program of keeping the public informed of the latest developments in residential lighting. Miss Freyer fills the vacancy created by the resignation of **Edith Buchholtz**, who in her six years as home lighting consultant with the department has established a national reputation through her lecture work and article writing. Miss Buchholtz is returning to her native Kansas.

Harry A. Winne, of Rexford, N. Y., retired Vice-President of General Electric Co., has been awarded the 1954 John Fritz Medal by the four founding engineering societies: The American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Civil Engineers. Mr. Winne was honored for "service to his country in war and peace through his distinguished leadership in the electrical industry." The Medal will be presented February 1, during the Winter General Meeting of AIEE in New York City.

Major changes in the General Electric Co.'s organization at the executive office level have been announced. They include the formation of the Distribution Group composed of the Apparatus Sales Division, the General Electric Supply Co., International General Electric Co., and the General Electric Credit Corp. The Affiliated and Foreign Companies Group is discontinued. Executive Vice-President **Henry V. Erben** has been appointed group executive in charge of the new Distribution Group, and Executive Vice-President **Robert Paxton** will succeed Mr. Erben as group executive in charge of the Apparatus Group. Canadian General Electric Co. becomes a part of the Apparatus Group. **John W. Belanger** has been elected an Executive Vice-President and put in charge of the Industrial Products and Lamp Group, succeeding Mr. Paxton. The X-Ray Department becomes a part of the Industrial Products and Lamp Group. The name of the Defense Products Group has been changed to the Atomic Energy and Defense Products Group, with group executive responsibility assigned to Vice-President **Cramer W. LaPierre**, who succeeds Mr. Belanger.

Robert Ligare has re-entered the lighting business by joining the sales staff of Allen & Olsen Co., 4230 Del Rey Ave., Venice, Calif. Before moving to California Mr. Ligare had been lighting consultant with the Chicago Lighting Institute for eight years.

Two promotions to top positions in the engineering division of Jefferson Electric Co., Bellwood, Ill., have been announced. **William C. Anderson** has been named chief project engineer. **Dr. Herbert O. Rost**, who joined the company two years ago as a research engineer, has been promoted to the position of chief development engineer.

William L. Hawley has been appointed Manager of Street Lighting Engineering and Development for Powerlite Devices, Ltd., Toronto. Mr. Hawley was formerly Manager of Product Planning for Lighting Equipment for the company.

The following appointments by the Lamp Division of Westinghouse Electric Corp., were effective December 1, 1954. **L. M. Wallace, Jr.**, was named manager of the St. Louis Lamp Sales District, which includes Arkansas, southern Illinois, eastern Missouri, western Tennessee, and northern Mis-

(Continued on page 24A)

(Continued from page 23A)

sissippi. Mr. Wallace was previously regional sales engineer for the southwestern region. **J. C. Gilmore** was named manager of the Texas Lamp Sales District, with headquarters in Dallas, and covering Texas, neighboring New Mexico, and eastern Arizona. Mr. Gilmore was formerly manager of the St. Louis District. **R. K. Leonard** has been appointed manager of the South Pacific Lamp Sales District, headquartered in Los Angeles. He most recently served as manager of the Texas District.

Appointment of **Roy R. Marchetti** as District Sales Engineer for the Cleveland office of Sola Electric Co., Chicago, has been announced. Mr. Marchetti will represent the company's entire product line in the Detroit-Cleveland area and throughout the greater part of Ohio and Southeastern Michigan. Mr. Marchetti succeeds **W. R. Freeman**, who has taken a position on the sales staff of McGraw-Hill Publishing Co. Sola also announces the appointment of **J. R. McGovern** as District Sales Engineer in Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, and Quebec, with headquarters in Toronto, Ont.

Marvin Manufacturing Co., Los Angeles, has appointed **Billy L. Cook** as representative for the states of Texas and Oklahoma. Mr. Cook's headquarters will be in Houston, Texas.

Robert M. Myers has been appointed industrial relations manager for the lighting division of Westinghouse Electric Corp., Cleveland. Mr. Myers succeeds **David A. McQuade**, who has been transferred to Boston, Mass., as industrial relations manager for the Sturtevant division of Westinghouse which manufactures air handling and ventilating equipment.

The appointment of **John H. Vier** as sales representative for Markel Electric Products, Inc., Buffalo, has been announced. Mr. Vier will act as an associate of **Louis Stark** who has represented Markel for over thirty years. The territory he will cover will be metropolitan New York, northeast Pennsylvania and northern New Jersey.

Ruben F. Mettler, 30, of the Hughes Aircraft Co., Culver City, Calif., now on loan to the Department of Defense in Washington, has been named the outstanding young electrical engineer of 1954 by Eta Kappa Nu, Electrical Engineering Honor Society. Formal presentation of the award takes place at the annual banquet of the Society, January 31, during the Winter General Meeting of the American Institute of Electrical Engineers, at the Statler Hotel, New York City.

Deaths

Sections and Chapters of the Illuminating Engineering Society report with sorrow the passing of the following members.

Thomas C. Booth (San Jacinto Section) Crouse-Hinds Company, Houston, Texas.

William W. Bracken (Southern California Section) S&M Lamp Company, Los Angeles, Calif.

Charles G. Gayney (Michigan Section) The Gayney Company, Detroit, Mich.

H. E. Johnson (Mexico Chapter) Electronics, S. A., Mexico, D. F., Mexico.

OBITUARY

Walter D. Steele, recently retired from the position of President of Benjamin Electric Mfg. Co., died December 9 following a coronary attack, at the age of 84. Mr. Steele had been a member of the Illuminating Engineering Society, continuously since 1907.

A pioneer in the electrical manufacturing industry, Mr. Steele with his associates organized Benjamin Electric Manufacturing in 1901, and in 1907 became Vice-President in Charge of Sales and Manufacturing Activities. He served as President of the company from 1928 until 1954, when he retired from active business in favor of a consulting capacity.

Mr. Steele was also active in the National Electrical Manufacturers Association, being twice elected to the Board of Governors, in 1931-1933 and again in 1936-1938. In 1942 he was awarded the association's 50-year medal, and in 1952 he became the first recipient of a 60-year medal for continuous and devoted service to the entire electrical industry.

Born in Keokuk, Iowa, and graduated from Iowa State College, in 1891, Mr. Steele was first associated with the Cast Iron Pipe Works of Cincinnati, and the Brush Electric Company. He later joined the City of Detroit and in 1896 became City Electrician, during which time he established a municipal inspection department under an ordinance of the City of Detroit.

In 1900 Mr. Steele joined Westinghouse, Church, Kerr and Company, in New York, where he had charge of design, specification and construction of a wide variety of projects.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, December 9, 1954, the following were elected to membership. Names marked * are transfers from Associate Member grade.

ARIZONA SECTION

Member:
Slade, L. W., Edward L. Varney Associates, Phoenix, Ariz.

Associate Members:
Mulsow, J. M., Arizona Public Service Co., Phoenix, Ariz.
Ruff, D. L., Arizona Public Service Co., Phoenix, Ariz.

ARK-LA-TEX CHAPTER

Associate Member:
Wright, W. M., Willard Wright Electric Co., Henderson, Texas.

BRITISH COLUMBIA SECTION

Associate Members:
Crompton, F. G., Canadian Westinghouse Supply Co., Ltd., Vancouver, B. C.
Stafford, J. W., Powerlite Devices Ltd., Vancouver, B. C.

CENTRAL NEW YORK SECTION

Associate Member:
Alpern, Jules, Superior Electric Corp., Syracuse, N. Y.

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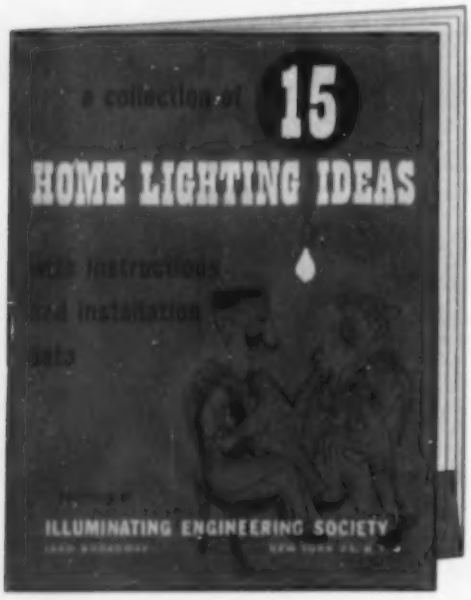

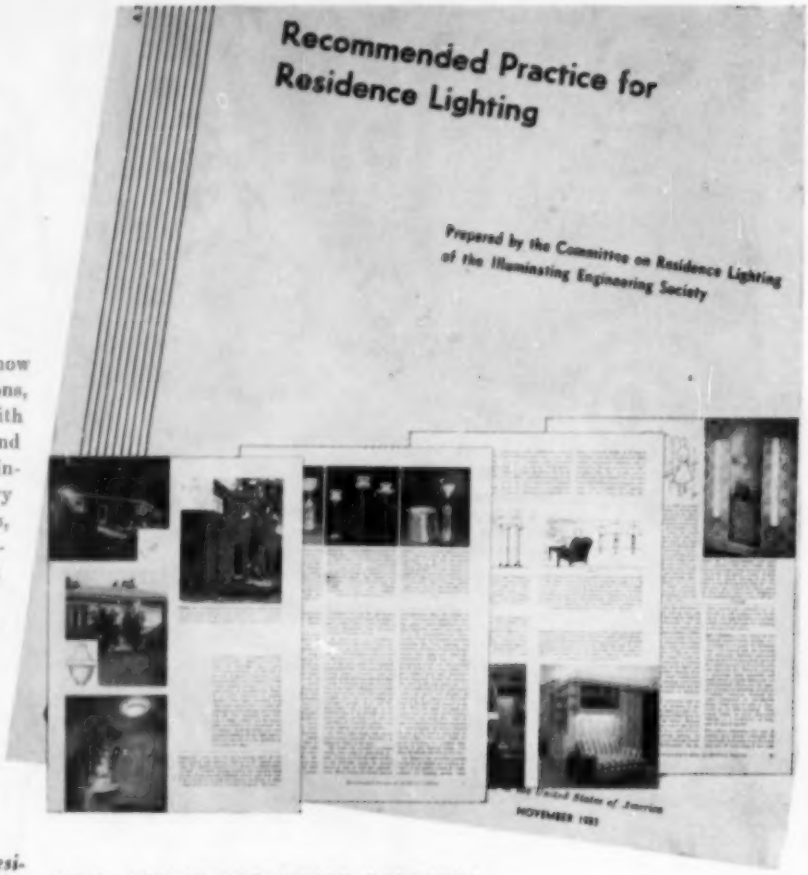
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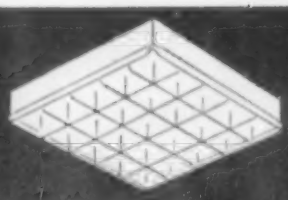

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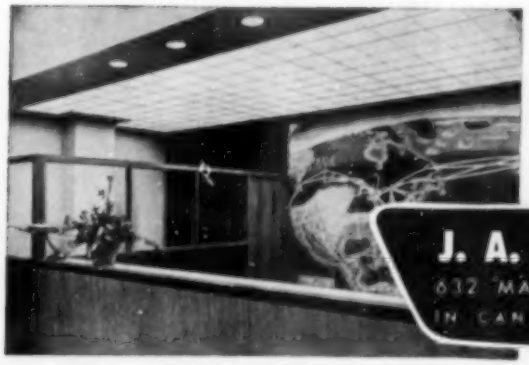

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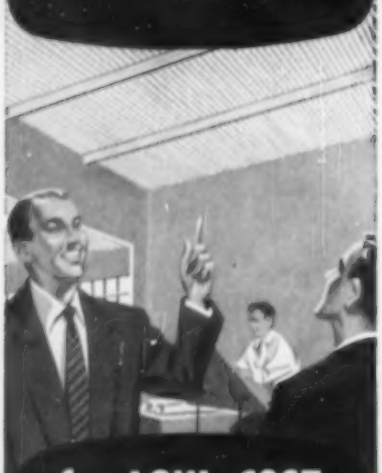

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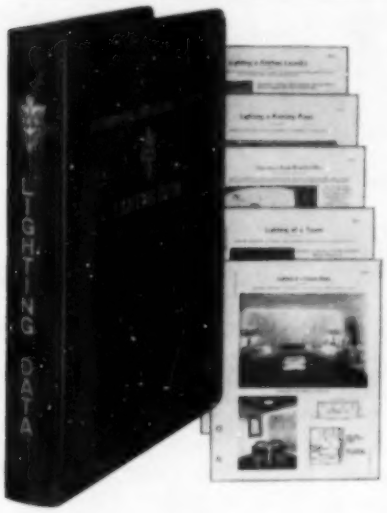

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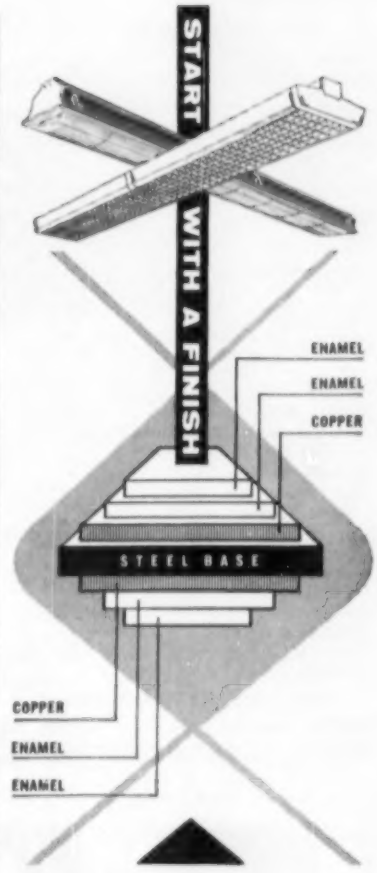

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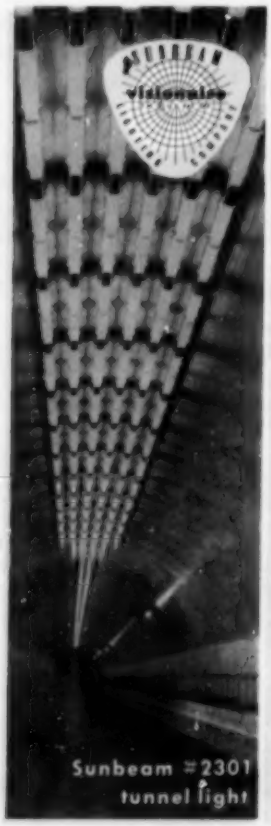

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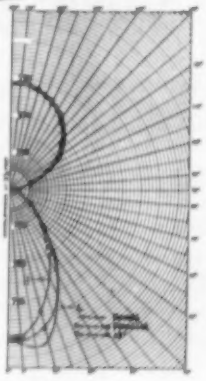

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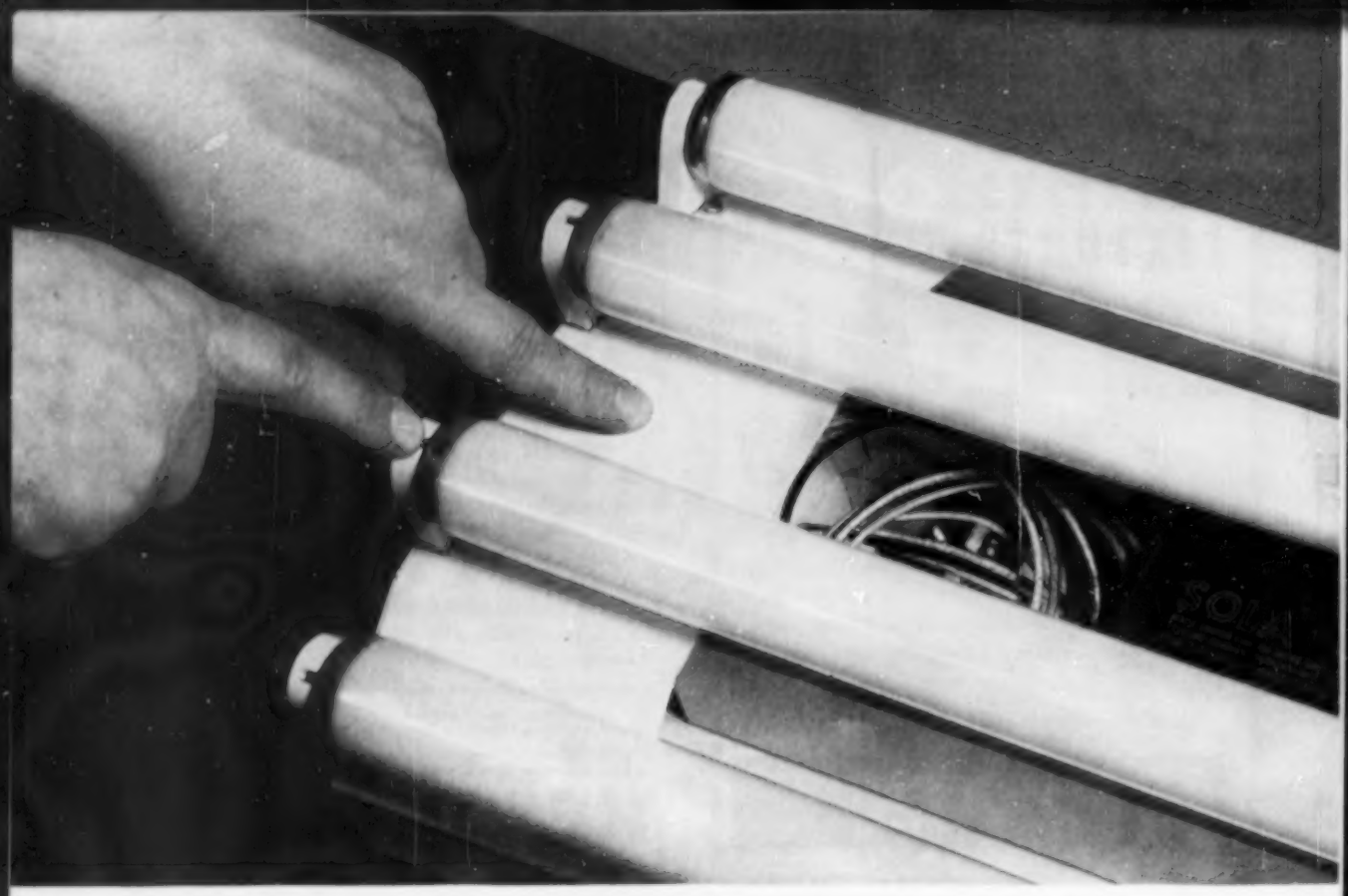

300 volts from lamp to ground for dependable starting of rapid-start lamps with Sola Constant Wattage Ballasts

The voltage from the electrode in a rapid-start fluorescent lamp to the grounded fixture (an important starting aid) is important for dependable starting. The higher this voltage, the more positive starting will be. Conventional, autotransformer-type rapid-start ballasts provide only 180v across lamp-to-ground. Sola Constant Wattage Ballasts provide 300v with *perfect safety*.

This extra 60% voltage from lamp to ground is one of the advantages that results from Sola's patented, double-wound, constant wattage circuit. In addition, lumen output is maintained constant within ±2% regardless of line voltage fluctuations from 106-130v.

Close the switch — a Sola ballasted rapid-start fixture will start even under adverse conditions of temperature, humidity and lamp age. This positive starting characteristic also prolongs lamp starting life.

If you manufacture fixtures, or specify, operate, or maintain lighting installations, look into the benefits of a constant wattage ballasted rapid-start system. A Sola sales engineer will be happy to give you all the facts.

Reduces relamping . . . keeps lumen output constant

SOLA *Constant Wattage* **BALLASTS**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Mercury Vapor Lighting • Plastic Signs
SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois, Bishop 2-1414 • NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464
PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • BOSTON: 272 Centre St., Newton 58, Mass., Bigelow 4-3334
CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400 • KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382 • Representatives in Principal Cities

Leading Manufacturers of Fluorescent Tubes say:

CERTIFIED CBM CERTIFIED by ETL BALLASTS

are Tailored to the Tube

No one knows better the value of CERTIFIED CBM BALLASTS than the manufacturers of fluorescent tubes. For the satisfactory performance of their lamps is vitally dependent on the ballasts that operate them. Here's what they say:

CHAMPION *says:*

"Fluorescent lamps are designed to operate at specific electrical values. The use of auxiliary equipment that has been proven to meet these agreed upon standards will assure the user maximum value for his lighting dollar with a minimum of operational failures. Certified Ballasts are inexpensive insurance."

GENERAL ELECTRIC *says:*

"The life and light output ratings of fluorescent lamps are based on their use with ballasts providing proper operating characteristics. Ballasts that do not provide proper electrical values may substantially reduce either lamp life or light output, or both. Ballasts certified as built to the specifications adopted by the Certified Ballast Manufacturers (CBM) do provide values that meet or exceed minimum requirements. This certification assures the lamp user, without individual testing, that lamps will operate at values close to their ratings."

SYLVANIA *says:*

"The light and life ratings of fluorescent lamps are based on three hour burning cycles under specified conditions and with ballasts meeting American Standards Association specifications. Ballasts marked with the CBM emblem and certified by Electrical Testing Laboratories, Inc., meet ASA specifications."

WESTINGHOUSE *says:*

"Use ballasts that are tested and Certified by Electrical Testing Laboratories or ones that are otherwise known to meet the specifications of the lamp manufacturer. These will give best results with Westinghouse fluorescent lamps."

By using fluorescent fixtures that are equipped with CERTIFIED CBM BALLASTS you are assured long lamp life, full light output and trouble-free operation.

That's why CERTIFIED CBM BALLASTS merit the slogan—Tailored to the Tube.

CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

here's why GrateLite* is great!

eye comfort you can measure
300 F.C. with only
1.11 C.P./Sq. In. Brightness

and here are the figures to prove it . . .

Foot-Candles, Efficiencies, Brightness Readings

Room No.	No. of 8' Lamps & Arr.	Total Lamp Watts	Foot-Candles: With Condition	Foot-Candles: Less Loss	Eff. With Condition	Brightness At 30°: F. L.°	Brightness At 30°: C. P./ Per Sq. In.	Brightness At 45°: F. L.°	Brightness At 45°: C. P./ Per Sq. In.
1	8 @ 200	1600W	300	240	70%	740	0.111	520	0.111
2	16 @ 200	3200W	150	120	72%	380	0.057	270	0.079
3	24 @ 200	4800W	75	60	70%	180	0.025	140	0.021
4	24 @ 430	10320W	325	170	70%	780	0.117	570	0.086
5	8 @ 200 + 24 @ 430	11920W	150	200	72%	360	0.054	250	0.038
6	8 @ 200 + 24 @ 430	11920W	300	230	73%	720	0.108	505	0.076
7	24 @ 200 + 24 @ 430	15360W	225	200	81%	540	0.081	380	0.057
8	48 @ 430	20640W	350	270	77%	840	0.126	590	0.088
9	8 @ 200 + 48 @ 430	22080W	255	145	70%	610	0.091	430	0.064
10	16 @ 200 + 48 @ 430	23520W	355	165	78%	850	0.127	600	0.090
11	24 @ 200 + 48 @ 430	25920W	300	200	77%	720	0.111	510	0.079

*F. L.—Foot Lamberts †C. P.—Candlepower *U. S. & Can. Pats. Pend. Trademark Registered

In our own showrooms we've installed a 15' x 16' GrateLite Ceiling. By switching on various lamp arrangements we can deliver from 28 to 300 foot-candles 7' 9" below the GrateLites. Measurements at right give GrateLite efficiency figures and brightness readings at 30° and 45° below the ceiling.

THESE FIGURES PROVE GRATELITE in a class by itself for modern high intensities, safely within comfort ranges plus a high degree of diffusion.

AREA: *15' x 16' (240 Sq. Ft.)*
GRATELITES: *Suspended 18" below ceiling*
FT.-CANDLES: *Taken 7' 9" below GrateLite*
BRIGHTNESS READINGS: *Taken with "Guth-Lite" Electronic Meter*
LUMINAIRES: *Guth M-5385/TO*
ROOM COLORS: *3 walls—light green—60% R. F. Floor—15% R. F.*

It's all in the sight-saving cubes—and only GrateLite has them!

Send for free booklet "The GrateLite Story" Also "Glare Fighters" and "Visual Comfort Indexes".

Guth EDWIN F. GUTH CO. • ST. LOUIS 3, MO.

Leaders in Lighting since 1902